Fraser River Estuary Monitoring

Report on the 1990 Lower Fraser River and Boundary Bay Sediment Chemistry and Toxicity Program

FRASER PORT

Province of
British Columbia

Other reports published by the B.C. Ministry of Environment - Fraser Port under the Fraser River Estuary Monitoring Program are the following:

Fraser River Estuary Monitoring, Summary Report of the 1986 Effluent Monitoring Program. Supervisory Coordinating Committee. October 1987. 34 pp.

Fraser River Estuary Monitoring, Report on the 1987 Benthos and Sediment Monitoring Program. Swain, L. G. and D. G. Walton. March 1988. 66 pp.

Fraser River Estuary Monitoring, Report on the 1988 Fish Monitoring Program. Swain, L. G. and D. G. Walton. March 1989. 147 pp.

Fraser River Estuary Monitoring, Report on the 1989 Fraser River Sediment Monitoring Program. Swain, L. G. and D. G. Walton. December 1990. 47 pp.

Fraser River Estuary Monitoring, Report on the 1989 Boundary Bay Sediment Monitoring Program. Swain, L. G. and D. G. Walton. December 1990. 172 pp.

ERRATUM

FRASER RIVER ESTUARY MONITORING, REPORT ON THE 1990 FRASER RIVER AND BOUNDARY BAY SEDIMENT CHEMISTRY AND TOXICITY PROGRAM, MAY 1991

FIGURE 1, PAGE 46
THE SITE SHOWN AS "B10 (E207870)" SHOULD BE LABELLED AS "B10 (E207872)".

REPORT ON THE 1990 LOWER FRASER RIVER AND BOUNDARY BAY SEDIMENT CHEMISTRY AND TOXICITY PROGRAM

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SUMMARY

During the past several years, the B.C Ministry of Environment through the Fraser River Harbour Commission, has measured contaminant concentrations in sediments collected from sites in the Fraser River and Boundary Bay. Where elevated contaminant concentrations were found, it was observed that generally, the particular sediment sample had a greater portion of the smallest particle size. While reviewing the analytical data, it was also found that criteria did not exist which could be used to determine if the measured concentrations were environmentally significant. The aims of the 1990 monitoring program were to:

(a) determine if elevated contaminant concentrations were associated with a particular particle size fraction.
(b) using sediment toxicity tests, determine if toxic properties were associated with a particular particle size fraction.

In June 1990, sediments were collected from four sites which we had previously sampled, three in the Fraser River and one in Boundary Bay. Three replicate sediment samples were obtained at each of the four sites. These samples were separated into two different particle size classes. Analytical tests were then performed on the size classes for a variety of organic and inorganic variables. Toxic properties associated with particular particle size classes were determined using the microtox bioluminescence and echinoderm (sand dollar) sperm cell bioassays.

Quality assurance and control programs were a very important consideration in this program. All samples were split into triplicate samples for all testing. The level of effort expended in the laboratory as a percentage for QA / QC amounted to 50% for guaiacols and catechols in sediments, 31% for the bioassays themselves, 25% for dioxins and furans, 33% for metals and organics in the analysis of the sediment samples and 36% for metals in leachate extractions, and 44% for organics in the leachate extractions.

In general, the sediments from the four sites had no particles greater than 2 mm in size, which means that the particles from all sites were fine textured. Those sediments in the range from 0.063

mm to 2 mm would be considered fine sands, while those smaller than 0.063 mm would be classed as silts and clays. The percentage of particles from the two particle sizes varied among the sites, with the largest amount of very fine particles (approximately 95%) being found at the North Arm site in the Fraser River and the smallest amount (approximately 25%) of very fine particles at the Barnston Island site. From our previous observations, we would expect to find the highest contaminant concentrations at the site with the largest percentage of very fine particles.

The concentrations of arsenic, copper, chromium, mercury, nickel, and zinc for the Fraser River sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present. Of interest is the fact that when the mean metal concentrations associated with a particular particle size were examined, the concentrations for every metal in the Fraser River sediments increased from upstream to downstream for both particle sizes.

In the sediments as sampled from the four sites, the highest concentrations of arsenic, cadmium, chromium, lead, and mercury for all four sites were at Site BB-10 which had less very fine particles than two of the three Fraser River sites. This may indicate a contamination problem in Boundary Bay with these metals.

For total organic and inorganic carbon, the lowest mean concentration was found at the Barnston Island site in the Main Stem and the largest mean concentration at the Ewen Slough site in the Main Arm. This same pattern existed for total volatile residue; however, the highest mean concentration was found at the offshore site in Boundary Bay.

The analytical results for metals in the sediments and the extracts were generally accurate in comparison to certified values. Exceptions to this, where results were low compared to certified values, were cadmium and lead values in the extracts, and chromium in sediments. Arsenic values in sediments were erratic, with values both higher and lower than the certified range.

Analytical precision (i.e., replicate analyses of samples split in the laboratory) was generally good (results within 20% of each other) for sediments and extracts. Exceptions were lead and nickel in sediments and copper, mercury, nickel, and zinc in extracts.

The metal values measured in the different particle ranges were close enough to each other that it could not be determined for the sediments or the extracts whether there was a relationship between particle size and concentration. It is believed that this is due to the analytical precision being as large as any measured difference in value, as well as problems of ensuring a truly homogeneous sample with the small volume of sediments used in the analyses.

Metal concentrations in the sediments were generally the same magnitude as measured in 1989 at the same sites, except those from Site MS-1 in the Main Stem of the Fraser River which were often lower in 1990 than previously measured.

The modified leachate extraction procedure increased concentrations of the following metals in the extraction water above background concentrations: cadmium, copper, and nickel at all the sites; and arsenic at the Boundary Bay site and zinc at the Boundary Bay site and at the North Arm site in the Fraser River.

Chlorophenols, organochlorine pesticides, and PCBs were not detectable in the sediment or leachate extractions. The non-detectable concentrations of chlorophenols and PCBs in the sediments were about the same as measured in 1989. Any toxicity which may occur likely would not be due to chlorophenols, organochlorine pesticides, or PCBs.

PAHs were not detected in the sediment extracts using the modified leachate extraction procedure. This means that PAHs may not be responsible for any toxicity which may be determined for these sediments. When compared to data for the same sites collected in our earlier studies, maximum concentrations for some PAHs were lower while maximum concentrations for other PAHs were higher. For PAHs which were detected in sediments, as was the case for metals, the mean PAH concentrations associated with a particular particle size increased from upstream to downstream for both particle sizes.

Tetrachlorocatechol and 3,4,5-trichlorocatechol were measured only in the sediments and not the leachate extracts, and were not found in measurable concentrations at any of the sites. Tetrachloroguaiacol and 2,4,5-trichloroguaiacol were only found at the Main and North arms.

Dioxins and furans were measured only in the sediments and not the leachate extracts. Some forms of dioxins and one furan measured in the sediments were above concentrations measured in the Fraser River upstream from Prince George, a site which would be considered not to be impacted significantly by human activity. It is possible that dioxins and furans may be responsible for toxicity which may be present: however, this is uncertain.

The sediments from all sites except the site in Boundary Bay were non-toxic, as indicated using a bioassay for acute toxicity, the microtox bioluminescence test and a bioassay for chronic toxicity, the sand dollar test. At the Boundary Bay site, toxicity was indicated with the sand dollar test in two of the three replicates for the finer sized particles and in one of the three replicates for the larger sized particles. There was no apparent reason for the toxicity, based upon an examination of the chemical testing on both the sediments and the extracts used for the test procedures. However, the sediment chemistry data for the two particle size fractions do point to the possibility of a number of metals and PAHs associated with the particle size fractions having the potential to cause the toxicity.

On the basis of the concentration of each metal in the leachate extract compared to the amount of that metal in the original sediment sample, preliminary results indicate that the preferential order of release of metals was cadmium, arsenic, mercury, nickel, copper, and zinc. There was no apparent trend for one class of particles to release more metals than the other class.

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To these people our thanks are expressed.

1. INTRODUCTION

On April 1, 1986, a five-year agreement was concluded between the Fraser River Harbour Commission and the B.C. Ministry of Environment (MoE). The agreement related to carrying out monitoring in the Fraser River Estuary area, based on a report prepared by the Working Committee on Fraser River Estuary Monitoring (1984). The estuary area under study is the Fraser River downstream from Kanaka Creek, and includes Boundary Bay and Sturgeon and Roberts Banks.

The purposes of the monitoring in 1990 were:

1. to determine if there was a significant difference in contaminant concentration in sediments between that measured for the total sediment sample and that measured in each of two different size fractions of the same sample, and

2. to determine if extracts prepared using the leachate extraction procedure were acutely or chronically toxic to test organisms.

Sediment samples were collected from four sites that had been studied previously for the concentrations of metals and organic contaminants (Swain and Walton 1990, Swain and Walton 1988, Swain 1986). Three of the sites were located in the Fraser River: at Barnston Island (MS-1) in the Main Stem, at a site in the North Arm (NA-1) and at Ewen Slough in the Main Arm (MA-2). The fourth site was an off-shore site in Boundary Bay (BB-10) near the International Boundary.

2. MATERIALS AND METHODS

2.1 FIELD METHODS

There were three sites used for monitoring in the Fraser River Estuary and one site in Boundary Bay (Figure 1). Sediments were collected with a Grab dredge, and emptied into a glass tray, if possible. The top layer of sediment (about 2.5 centimetres) is taken off, forming a composite sample from at least three individual grab samples. The tray and scraper were rinsed with on-site water between samples. Between sites, the tray and scraper were rinsed with tap water carried in glass jars, then acetone, and finally hexane. The utensils were then allowed to air dry. At stations where the glass tray could not be used, care was taken to ensure that the sediment had not contacted plastic or wood. Large pieces of wood debris were removed from the samples, as was necessary.

Samples were placed into one litre glass jars which had been acid-washed, solvent-rinsed, and baked in an oven at 250° C. The lids of the jars were teflon-lined. All sediments were kept cool and refrigerated as possible, prior to delivery to, and upon receipt at, the laboratory. The samples for each site were subsequently mixed to homogeneity in the laboratory prior to being sub-divided into three.

2.2 ANALYTICAL METHODOLOGY

Much of what follows has been taken directly from the report prepared for the Fraser River Harbour Commission by the contract laboratory, Analytical Service Laboratories (ASL).

2.2.1 SAMPLE PREPARATION AND STORAGE

When the samples were received at the laboratory, they were catalogued, and sediment samples were kept cool until analyzed. The samples were prepared in a clean environment dedicated to this project. Sediment samples from each site were blended and sub-sampled to ensure a representative portion was taken for analysis. This was accomplished by taking an approximate 200 gram sub-sample from the larger container after stirring the sediment in that container, and then blending the sample until it was visibly uniform.

The sediments and sediment extracts were prepared using apparatus pre-cleaned with the methods used for the glass jars. Each of the twelve sediment samples (4 sites with three replicates per site) were prepared to produce three size fractions for each sample, for a total of 36 samples. A representative portion of each sample was air-dried so as to minimize loss of volatile components. The air-dried portion was homogenized and sieved to obtain appropriate amounts of the following size classes: total sediment sample, fine sand in the range from 63 microns to 2 mm, and silt and clay being defined as those particles less than 63 microns in size. The sieved sub-samples were again homogenized prior to further analyses.

The leachate extraction procedure was then carried out on prepared sediment fractions using a slightly modified procedure . The water used for the extracts was seawater from Outer Burrard Inlet. No pH adjustment was used through the leachate extraction procedure. Extracts were then submitted to the Aquatic Toxicity Laboratory in North Vancouver, including some samples to which reference toxicants were added as a QA measure.

Appropriate sediment sub-samples were selected and submitted to Seakem for analysis of dioxins and furans.

2.2.2 SEDIMENT ANALYTICAL PROCEDURES

2.2.2.1 Metals

All samples were analyzed using procedures outlined in Tetra Tech (1986). Specifically, a representative sub-sample (5 to 10 grams wet-weight, depending upon the moisture content and the uniformity of the sub-sample) of homogenized sediment was digested using a combination of nitric and hydrochloric acids. Analyses were subsequently done using atomic absorption techniques, as outlined in the following table.

Element	Instrument Detection Mode
As,Cd, Pb	Perkin Elmer Model MHS-20 hydride generation system coupled to a Model 2380 AA dual beam spectrophotometer equipped with automatic background correction.
Cr,Cu, Fe, Mn, Mg,Mo, Ni, Zn	Perkin Elmer Model P-40 inductively coupled argon plasma spectrograph.
Hg	Pharmacia Model U.V. mercury monitor with a 30 cm absorption cell.

2.2.2.2 Chlorinated Phenols

A representative portion of each sample (25 to 40 grams wet-weight, depending upon the moisture content and the uniformity of the sub-sample) was extracted using a modification of a technique published by Tetra Tech (1986). This procedure involves the soxhlet extraction of the sample with acidified hexane/acetone followed by solvent partitioning. The crude extract was then cleaned-up using Sephadex QAE-A25 ion exchange resin (Renberg, 1974). The resulting extracts were then derivatized using heptafluorobutyric anhydride and analyzed by capillary gas chromatography with electron capture detection, under the following conditions:

Instrument:	Hewlett Packard Model 5890A
Columns:	HP-1, 25 metres long by 0.32 mm i.d. by 0.17 µm film thickness HP-5, 25 metres long by 0.32 mm i.d. by 0.17 µm film thickness
Oven:	100 °C hold for 1 minute, then 5 °C/minute to 200 °C, hold for 5 minutes.

2.2.2.3 PCBs and Organochlorine Pesticides

A representative portion of each sample (the same 25 to 40 grams wet-weight used for the chlorophenol analysis) was extracted using a modification of a technique published by Tetra Tech (1986). This procedure involves the soxhlet extraction of the sample with acidified hexane/acetone followed by solvent partitioning. The crude extract was then cleaned-up by alumina column chromatography producing various fractions containing the PCBs, pesticides, and phthalate esters. The resulting extracts were analyzed using capillary gas chromatography equipped with dual column/dual electron capture detection under the conditions outlined in Section 2.2.2.2, with the following modifications:

Oven:	Fraction 1: 150 °C hold for 3 minutes, then 3 °C/minute to 210 °C, hold for 7 minutes Fraction 2: 200 °C hold for 1 minute, then 3 °C/minute to 230 °C.
Injection:	2 µL (splitless)

2.2.2.4 PAHs

A representative portion of each sample (a portion of the same 25 to 40 grams wet-weight used for the other organic analyses) was extracted using a modification of Procedure 21.001 (AOAC 1984). This involves the saponification of the sample with ethanolic potassium hydroxide followed by solvent partitioning into iso-octane. This crude extract was then subjected to a clean-up procedure using phosphoric acid and solvent partitioning between iso-octane and dimethyl sulfoxide. A further clean-up procedure using silica gel column chromatography (EPA Method 610, U.S. EPA, 1984) was also employed. The resulting extract was then analyzed by capillary gas chromatography with mass spectrometer detection, under the following different conditions than outlined in Sections 2.2.2.2 and 2.2.2.3.

Instrument:	Hewlett Packard Model 5880
Oven:	80 °C, hold for 1 minute, then 7 °C/minute to 260 °C , hold for 10 minutes.

2.2.2.5 Moisture Content

A representative portion of the sample (5 to 10 grams) was dried to a constant weight at 105 °C. Moisture was then determined gravimetrically by measuring weight loss upon drying.

2.2.2.6 Total, Organic, and Inorganic Carbon

A representative portion of each sample (5 to 10 grams) was leached with hydrochloric acid to remove carbonates and then analyzed for organic carbon using a Leco induction furnace. Total inorganic carbon was determined as the difference between total and organic carbon.

2.2.2.7 Particle Size

Representative portions of each sample (5 to 10 grams) were dry sieved in accordance with Tyler (1980), and the fine materials determined by pipette method (Tanner and Jackson, 1947).

2.2.2.8 Total Volatile Residue

Determined gravimetrically after igniting the sample at 550 °C for one hour and cooling in a vacuum desiccator.

2.2.2.9 Chlorinated Guaiacols and Catechols

Chlorinated guaiacols and catechols were analyzed according to a procedure based on Renberg (1974). The air-dried samples were extracted with acidified acetone and the combined extracts diluted with brine. This mixture was then extracted with hexane and concentrated to a final volume of 2 to 3 mL. The concentrated extract was passed through a solid phase extraction tube previously conditioned with hexane. The column was then washed with hexane prior to elution of phenols with one column volume of acidified diethyl ether. The ether elutant was washed with a small portion of brine, dried and then solvent-exchanged to hexane. The final extract was then acetylated and analyzed by gas chromatography with dual electron capture detection (dual capillary column).

2.2.2.10 Dioxins / Furans

All samples for dioxin and furan analysis were analyzed by Seakem Analytical Services Ltd. All samples were spiked with an aliquot of ^{13}C labelled internal standard solution prior to analysis. This aliquot contained 2 ng each of ^{13}C labelled tetrachlorodibenzodioxin, tetrachlorodibenzofuran, and pentachlorodibenzodioxin; 4 ng each of ^{13}C labelled hexachlorodibenzodioxin and heptachlorodibenzodioxin; and 6 ng of ^{13}C labelled octachlorodibenzodioxin.

The wet sediment sample (10 to 15 grams wet-weight) was ground with anhydrous sodium sulphate and allowed to stand until the mixture ground to a free-flowing powder. It was then loaded into a soxhlet thimble and an aliquot of internal standard solution added. The soxhlet was re-fluxed for 20 hours with 300 mL of 80 : 20 toluene : acetone.

The extracts were then subjected to a series of cleanup steps and then analyzed by gas chromatography with mass spectrometric detection.

2.2.3 LEACHATE EXTRACT ANALYSES

2.2.3.1 Metals

Metals were analyzed in accordance with "Standard Methods For the Examination of Water and Wastewater" (APHA 1985). For most metals, optimized non-flame absorption techniques were used.

2.2.3.2 Chlorinated Phenols

A representative portion of each liquid extract sample was prepared for analysis by further laboratory extraction techniques using a modification of the procedure given in the Puget Sound Protocols. This procedure involves the soxhlet extraction of the sample with acidified hexane/acetone followed by solvent partitioning. The crude extract was then cleaned-up using Sephadex QAE-A25 ion exchange resin. The resulting extracts were then derivatized using acetic anhydride and analyzed by gas chromatography with electron capture detection.

2.2.3.3 PCBs and Organochlorine Pesticides

The liquid extract sample was analyzed in accordance with U.S. EPA Method 608. This procedure involved the further laboratory extraction of the sample with dichloromethane (DCM) followed by column chromatography clean-up. The concentrated extract (1 or 2 µL) was then analyzed using a gas chromatograph equipped with electron capture detection.

2.2.3.4 PAHs

The sample was analyzed in accordance with U.S. EPA Method 610. This procedure involved the extraction of the sample with dichloromethane (DCM) followed by column chromatography clean-up. The resulting extract (1 or 2 µL) was then analyzed using a gas chromatograph with flame ionization detection.

2.2.3.5 Toxicity Testing

The extracts were used to perform two different bioassay test procedures; the echinoderm bioassay and the microtox bioluminescence bioassay.

The echinoderm bioassay was performed following the procedures outlined in Van Aggelen (1990). All bioassays were conducted using sand dollars (Denaster excentricus) collected at low tide on Crescent Beach. The animals were held in flowing sea water and sediment from the collection site prior to the tests and for control purposes. All bioassays were conducted at the Toxicology Laboratory in North Vancouver.

The microtox bioluminescence bioassay procedure followed the Standard Assay Procedure prepared for a Microtox Inter-Laboratory Comparison Study (File 2600-BK3-13).

2.3 QUALITY ASSURANCE / QUALITY CONTROL

The following is based upon information provided by ASL Laboratories. The U.S. EPA define Quality Assurance (QA) as the "total program for assuring the reliability of monitoring data".

Quality control (QC) is limited to "the routine application of procedures for controlling the measurement process." QA is concerned primarily with the tools of the measurement system. Reagents of the highest quality were used and checked for purity, strength, deterioration with time, and contamination. Class A volumetric glassware was thoroughly cleaned and calibrated when necessary. Balances were checked frequently with certified weights and records maintained. All instruments were calibrated on a routine basis, with the maintenance of appropriate standards and operational logs on performance.

Extensive QA measures were taken to ensure that the highest level of precision and accuracy was maintained. All analyses were performed using accepted procedures and included the concurrent analysis of reagent blanks, sample duplicates, analyte spikes, and certified reference materials, where available. Further detailed discussion of the precision and accuracy for each type of analysis is included in the following chapter.

Precision of guaiacols and catechols in sediments was determined using two duplicate analyses, while contamination was assessed using two blank samples. Two spiked samples were also used to determine the percent recovery at concentrations of 4 µg/kg (dry-weight).

Precision of the two bioassay procedures was tested by running seven duplicate bioassays with each test procedure. To ensure contamination was not occurring, four blank samples were examined with each bioassay test procedure. As well, three different reference toxicants were used during the testing. These were dehydroabietic acid (DHA), cadmium, and copper. The DHA did not work well as it precipitated in the sea water. The cadmium samples caused toxicity which impaired the ability to use it as a reference toxicant. The copper standards worked well, with a mean FID50 (concentration at which there is a 50% fertilization inhibition) of 0.06 mg/L which is in close agreement to values cited for previous work (Dinnel 1987) of 0.045 mg/L.

Dioxins and furans in sediments were checked by calculating the surrogate standard recovery for five dioxins and one furan.

Accuracy was determined for metals by measuring levels in two different certified reference sediment samples; one was a marine sediment prepared by the National Research Council of Canada, and the second being an estuarine sample from the National Bureau of Standards in the USA. Accuracy of the metals concentrations in the leachate extractions was determined by comparing a measured value to certified standards from one of four agencies. Reference materials were not available for organics.

Precision was determined for metals by running four digestion blanks and four duplicate analyses for metals in sediments, and five reagent blanks and seven duplicate analyses for leachate extractions. For organic analyses, four extraction blanks, analyte spikes, and duplicate analyses were tested for sediments, as well as five extraction blanks, four analyte spikes, and seven duplicate analyses for leachate extracts.

In total, the level of effort extended in the laboratory itself as a percentage for QA / QC amounted to 33% for metals and organics in the analysis of the sediment samples and 36% for metals in leachate extracts and 44% for organics in the leachate extracts.

For metals, only a minor amount of mercury was detected in one of four digestion blanks, indicating good contamination control. Further discussion is included for each characteristic in the appropriate section. Where the discussion relates to the precision of duplicate analyses, the percent difference between values is calculated as the difference divided by the smaller of the two values. This produces larger, and hence more conservative numbers than if the average or maximum values were used in the calculation.

For the organic analyses, nothing was detected in the extraction blanks. Further discussion is included for each characteristic in the appropriate section.

3. RESULTS AND DISCUSSION

In the following discussion, when at least one-half of the results are above the detection limit, average values and corresponding standard deviations have been calculated. In cases where values are less than the minimum detectable concentration, the absolute value of the detection limit has been used to calculate average values. If more than one-half of the results are below the detection limit, average values and standard deviations are not calculated since there is too much uncertainty with so many values less than detection.

Values cited for sediments are as dry-weight, unless otherwise noted. The laboratory (ASL) reported that no technical problems were encountered with any of the sediment analyses.

3.1 PHYSICAL CHARACTERISTICS OF SEDIMENTS

The physical characteristics of the sediments are summarized in Table 1. Generally speaking, the sediments from the four sites had no particles greater than 2 mm in size, which means that the particles from all sites were fine textured. Those sediments in the range from 0.063 mm to 2 mm would be considered fine sands, while those smaller than 0.063 mm would be classed as silts and clays.

The percentage of particles from the two particle sizes varied among the sites, with the largest amount of very fine particles (approximately 95%) being found at the Upper North Arm site (Site NA-1) and the smallest amount (approximately 25%) of very fine particles at Site MS-1, at Barnston Island. If the concentrations of contaminants at the four sites were about the same, one would expect to find the highest concentrations at the site with the largest percentage of very fine particles.

For total organic and inorganic carbon, the lowest mean concentration was found at the Barnston Island site (Site MS-1) in the Main Stem and the highest mean concentration at the Ewen Slough site in the Main Arm (Site MA-2). This same pattern existed for total volatile residue; however, the highest mean concentration was found at the offshore site in Boundary Bay (Site BB-10).

The amount of organic material in the sediments, as indicated by the volatile residue, did not exceed 5% at any of the sites.

3.2 METALS AND METALLOIDS

The trace metals are presented in alphabetical order in the following sections. All data for individual samples are in a limited number of final reports from the analytical laboratory, and on the Ministry of Environment computerized data storage and retrieval system. Discussion of metals is limited to those considered to be priority toxicants.

Four digestion blanks were analyzed for all metals in sediments. For contamination to be present, measurable quantities would be present in these digestion blanks. None were measured above the following detection limits (dry-weight) except for one mercury (0.005 µg/g):

As	0.01 µg/g	Cd	0.25 µg/g
Cr, Cu, Mn, Mg, Zn	0.5 µg/g	Fe, Pb	2.5 µg/g
Mo, Ni	1.5 µg/g	Hg	0.005 µg/g

Since little or no contamination appears to be present due to the digestion process, corrections were not made to the data values reported by the laboratory.

Five blanks were analyzed for all metals in the leachate extracts. For contamination to be present, measurable quantities would be present in these digestion blanks. The following metals were not detected in the blank samples: cadmium (<0.0005 mg/L), chromium (<0.001 mg/L), iron (<0.05 mg/L), lead (<0.001 mg/L), manganese (<0.010 mg/L), nickel (<0.001 mg/L), and zinc (<0.005 mg/L). All the other metals were detected in at least one blank as follows:

Metal	Number Detected	Maximum	Minimum (mg/L)	Mean (+ Median)
Arsenic	5	0.0014	0.0007	0.0011
Copper	2	0.002	<0.001	<0.001+
Magnesium	5	1060	993	1020
Mercury	2	0.00015	<0.00005	<0.00005+
Molybdenum	5	0.005	0.003	0.004

Since little or no contamination appears to be present due to the digestion process, corrections were not made to the data values reported by the laboratory. However, these concentrations will be considered as the system detection limit when the data are to be interpreted in the later sections of this report. The presence of magnesium in all the samples is a result of using seawater to perform the leachate extractions.

3.2.1 ARSENIC

3.2.2.1 Arsenic in Sediments

For accuracy of arsenic values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(a)), arsenic values in sediments were slightly outside the certified range of values. In terms of analytical precision, as determined using four duplicate analyses of different sediment samples from the survey (Figure 3(a)), values were generally within 15% of each other or lower at higher concentrations.

Thus, these data indicate that the results reported here for arsenic in sediments may be inaccurate but precise within at least 15%.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. The calculated values for the mean arsenic concentration are compared to the actual value below.

Arsenic in Sediments (µg/g)

Site	Calculated	Actual
MS-1	3.90	5.03
NA-1	7.30	7.17
MA-2	7.88	6.50
BB-10	10.0	11.5

These data indicate that the differences between the actual and calculated were from about 1.5% to almost 30%. The discrepancies probably can be explained by analytical precision and the possibility that the samples may not be entirely homogeneous.

Arsenic concentrations measured in the sediments from these sites were similar to those measured in 1989 in the Fraser River (Swain and Walton 1990a) and in Boundary Bay (Swain and Walton 1990b) using the same analytical laboratory. The concentrations for the Fraser River sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present. The highest concentrations were at Site BB-10 which had less very fine particles than two of the three Fraser River sites. This may indicate an arsenic contamination problem in Boundary Bay.

When the mean concentrations in the same particle size fraction are compared, an increase in arsenic concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 3.77 µg/g at MS-1 to 6.83 µg/g at NA-1 and 8.50 µg/g at MA-2, while for the particle fraction smaller than 0.063 mm, values were 4.27 µg/g, 7.33 µg/g, and 7.83 µg/g, respectively.

3.2.2.2 Arsenic in Extract Samples

For the extracts, the one analysis of a certified reference standard gave virtually the identical result as was required, 0.15 mg/L compared to the certified value of 0.146 mg/L. In terms of analytical precision as determined using seven duplicate analyses of different extract samples from the survey, values were generally within 8% of each other.

In theory, for any site, the value measured in the extract for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision and assuming that extraction is proportional to the amount of the metal in the sediment. The comparison is shown below.

Arsenic in Extracts (mg/L)

Site	Calculated	Actual
MS-1	0.0010	0.0011
NA-1	0.0012	0.0010
MA-2	0.0012	0.0012
BB-10	0.0130	0.0140

This seems to be what was measured in this survey, and considering the problems encountered in trying to rationalize values in sediments using this technique, is a surprising finding. The concentrations measured in all the extracts, except those from the offshore site in Boundary Bay, Site BB-10 which had the highest concentrations in sediments, were near the concentrations measured in the blank samples (Section 3.2). This likely indicates that the leachate extraction failed to release considerable quantities of arsenic from the sediments below a background arsenic concentration in sediments of about 10 µg/g.

The actual release of arsenic from sediments into the leachate on a mg/L for every µg/g arsenic in the sediment for the two particle size classes is noted in Table 14. Values could only be calculated for Site BB-10, since concentrations in the leachate extracts for the other sites were above the maximum arsenic concentration in the seawater blanks. The amount of arsenic extracted from the sediment for particles less than 0.063 mm was about twice that found for particles between 0.063 mm and 2 mm in size.

3.2.3 CADMIUM

3.2.3.1 Cadmium in Sediments

For accuracy of cadmium values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(b)), cadmium values in sediments were approximately the same as the certified range of values. In terms of analytical precision, as determined using four duplicate analyses of different sediment samples from the survey (Figure 3 (b)), values were generally within 18% or better of each other.

Thus, these data indicate that the results reported here for cadmium in sediments are accurate and precise within about 15%.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. This was not readily apparent for data (Table 2) for any of the sites for cadmium. The discrepancies can be explained partly by analytical precision and partly by the possibility that the samples may not have been homogenized sufficiently.

Cadmium concentrations measured in the sediments from these sites were similar to those measured in 1989 in the Fraser River (Swain and Walton 1990a) and in Boundary Bay (Swain and Walton 1990b) using the same laboratory. The concentrations for the Fraser River sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at MA-2, which had the second highest amount of very fine particles present. The highest concentrations were at Site BB-10 which had less very fine particles than two of the three Fraser River sites. This may indicate a cadmium contamination problem in Boundary Bay.

When the mean concentrations in the same particle size fraction are compared, an increase in cadmium concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from a median of <0.25 µg/g at MS-1 and NA-1 to 0.55 µg/g at MA-2, while comparable values for particles smaller than 0.063 mm were <0.25 µg/g, <0.25 Mg/g, and 0.58 µg/g, respectively.

3.2.3.2 Cadmium in Extract Samples

For the extracts, the one analysis of a certified reference standard gave a result of 0.20 mg/L compared to the certified value of 0.263 mg/L. Therefore, cadmium values reported for the extracts are likely lower than the true value. In terms of analytical precision as determined using seven duplicate analyses of different extract samples from the survey, cadmium values were as different as 20% of each other.

In theory, for any site, the value measured in the extract for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision and assuming that extraction is proportional to the amount of the metal in the sediment. This did not appear to occur in the extracts as is shown below.

Cadmium in Extracts (mg/L)

Site	Calculated	Actual
MS-1	0.0025	0.0019
NA-1	0.0041	0.0029
MA-2	0.0026	0.0047
BB-10	0.0016	0.0022

Cadmium was not detected in the seawater blank samples (<0.0005 mg/L). The fact that concentrations considerably higher than the blank sample concentrations (Table 3) were found in the leachate extractions for all four sites indicates that cadmium was being released from the sediments.

The actual release of cadmium from sediments into the leachate on a mg/L for every µg/g cadmium in the sediment for the two particle size classes is noted in Table 14. Values could only be calculated for Sites MA-2 and BB-10, since concentrations in the sediments for the other sites were below the detection limit of 0.25 µg/g. The amount of cadmium extracted from the sediment for particles less than 0.063 mm was about 1.5 to 2.5 times greater than that found for particles between 0.063 mm and 2 mm in size.

3.2.4 CHROMIUM

3.2.4.1 Chromium in Sediments

For accuracy of chromium values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(c)), chromium values in sediments were outside the certified range of values and generally low. In terms of analytical precision as determined using four duplicate analyses of different sediment samples from the survey (Figure 3(c)), values were generally within 10% of each other or lower at higher concentrations.

Thus, these data indicate that the results reported here for chromium in sediments may be low but will be precise for sediments.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. The data below compare the actual value to that predicted by calculation.

Chromium in Sediments (µg/g)

Site	Calculated	Actual
MS-1	45.1	43.3
NA-1	60.0	59.8
MA-2	66.2	54.8
BB-10	62.7	60.4

These data indicate that the percentage difference between the actual and calculated were from less than one percent at NA-1 to about 20% at MA-2. These discrepancies can be explained by analytical precision and the possibility that the samples were not homogenized sufficiently.

Chromium concentrations measured in the sediments from these sites were similar to those measured in 1989 in the Fraser River (Swain and Walton 1990a) and in Boundary Bay (Swain and Walton 1990b) using the same laboratory. The concentrations for the Fraser River sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present. The highest concentrations were at Site BB-10 which had less very fine particies than two of the three Fraser River sites. This may indicate a chromium contamination problem in Boundary Bay.

When the mean concentrations in the same particle size fraction are compared, an increase in chromium concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 45.3 µg/g at MS-1 to 59.4 µg/g at NA-1 and 61.1 µg/g at MA-2, while those for the smaller particle range of <0.063 mm were 44.7 µg/g, 60.1 µg/g, and 68.9 µg/g, respectively.

3.2.4.2 Chromium in Extract Samples

For the extracts, the one analysis of a certified reference standard gave a result of <0.001 mg/L compared to the certified value of 0.00012 mg/L. In terms of analytical precision as determined using seven duplicate analyses of different extract samples from the survey, all the values were identical at <0.001 mg/L. This was also the value measured in all the extracts and the seawater blank samples. This indicates that chromium was not released in considerable quantities using the leachate extraction procedure, and that the detection limit for the test was too high to show anything.

3.2.5 COPPER

3.2.5.1 Copper in Sediments

For accuracy of copper values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(d)), copper values in sediments were within the certified range of values. In terms of analytical precision, as determined using four duplicate analyses of different sediment samples from the survey, copper values were generally within 10% of each other or lower at higher concentrations.

Thus, these data indicate that the results reported here for copper in sediments are accurate and precise.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. The data comparing the actual mean value and that predicted by calculation are below.

Copper in Sediments (µg/g)

Site	Calculated	Actual
MS-1	25.8	26.1
NA-1	43.3	45.8
MA-2	49.2	40.5
BB-10	34.1	35.5

These data indicate that the differences between the actual and predicted were from about one percent at MS-1 to 21.5% at MA-2. These small discrepancies can be explained by analytical precision which may result in part from the difficulty of obtaining truly homogeneous samples.

Copper concentrations measured in the sediments from these sites were similar to those measured in 1989 in Boundary Bay (Swain and Walton 1990b) and in the three Fraser River sites except Site MS-1, where the 1990 concentrations were lower than found in 1989 (Swain and Walton 1990a) using the same laboratory. The concentrations for the Fraser River and Boundary Bay sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present.

When the mean concentrations in the same particle size fraction are compared, an increase in copper concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 25.1 µg/g at MS-1, to 44.7 µg/g at NA-1 and 47.4 µg/g at MA-2, while those in the smaller particle range of less than 0.063 mm were 27.9 µg/g, 43.2 µg/g, and 49.9 µg/g, respectively.

3.2.5.2 Copper in Extract Samples

For the extracts, the one analysis of a certified reference standard gave virtually the identical result as was required, 0.12 mg/L compared to the certified value of 0.116 mg/L. In terms of analytical precision as determined using seven duplicate analyses of different extract samples from the survey, copper values were as different as 40% of each other. However, this percentage represents precision only near the detection limit since the measured values are close to the detection limit.

In theory, for any site, the value measured in the extract for the total sample should be about the same as the sum of the weighted results for the two particle sizes (Table 3), taking into account analytical precision and assuming that extraction is proportional to the amount of the metal in the sediment. This was not what was measured in the extracts (see below) at Sites NA-1 or BB-10, possibly due to the amount of contamination present (Section 3.2) and problems with analytical precision.

Copper in Extracts (mg/L)

Site	Calculated	Actual
MS-1	0.0030	0.0033
NA-1	0.0057	0.0043
MA-2	0.0040	0.0037
BB-10	0.0067	0.0053

Copper concentrations were higher in the extracts than in the seawater blanks, which had concentrations of <0.001 mg/L or 0.002 mg/L. The highest copper concentrations were measured in the extracts of the smallest particles (0.063 mm) from Site BB-10 in Boundary Bay, with a maximum concentration in the extract of 0.0150 mg/L (Table 3). Thus considerable amounts of copper are being released from sediments (up to 0.013 mg/L) using the leachate extraction procedure.

The actual release of copper from sediments into the leachate on a mg/L for every µg/g copper in the sediment for the two particle size classes is noted in Table 14. The values have had corrections applied to the concentrations in the leachate extracts with compensation for the maximum copper concentration in the seawater blanks. The amount of copper extracted from the sediment for particles less than 0.063 mm was about twice that found for particles between 0.063 mm and 2 mm in size for Site BB-10; however, it was identical at the other three sites.

3.2.6 LEAD

3.2.6.1 Lead in Sediments

For accuracy of lead values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(f)), lead values in sediments were within or slightly lower than the certified range of values. In terms of analytical precision as determined using four duplicate analyses of different sediment samples from the survey (Figure 3(e)), lead values were generally within 40% of each other at values up to 10 µg/g but within about 10% at higher concentrations.

Thus, these data indicate that the results reported here for lead in sediments will be accurate and precise at most sites except Site MS-1.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. This was not readily apparent for data for any of the sites for lead, as shown below. This may be explained by analytical precision or the difficulty in ensuring that the samples are homogenized sufficiently.

Lead in Sediments (µg/g)

Site	Calculated	Actual
MS-1	5.50	3.83
NA-1	12.4	8.83
MA-2	14.7	13.2
BB-10	21.5	18.8

These results represent differences between the actual and calculated values from 10.6% for Site MA-2 to 44.4% for Site MS-1.

Lead concentrations measured in the sediments from these sites were similar to those measured in 1989 in Boundary Bay (Swain and Walton 1990b) and in the three Fraser River sites except Site MS-1, where the 1990 concentrations were lower than found in 1989 (Swain and Walton 1990a) using the same laboratory. The concentrations for the Fraser River sites seem to be related partly to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at MA-2, which had the second highest amount of very fine particles present. The highest concentrations were at Site BB-10 which had less very fine particles than two of the three Fraser River sites. This may indicate a lead contamination problem in Boundary Bay.

When the mean concentrations in the same particle size fraction are compared, an increase in lead concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 4.33 µg/g at MS-1, to 9.0 µg/g at NA-1, and 15.3 µg/g at MA-2, while those for the smaller particles sized less than 0.063 mm were 9.0 µg/g, 12.5 µg/g, and 14.7 µg/g, respectively.

3.2.6.2 Lead in Extract Samples

For the extracts, the one analysis of a certified reference standard gave a value of 0.19 mg/L compared to the certified value of 0.245 mg/L. In terms of analytical precision, as determined using seven duplicate analyses of different extract samples from the survey, all values were <0.001 mg/L. This was the value measured in all the extracts for all the particle sizes, indicating that lead was not released using the modified leachate extraction procedure.

3.2.7 MERCURY

3.2.7.1 Mercury in Sediments

For accuracy of mercury values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(i)), mercury values in sediments were within the certified range of values. In terms of analytical precision, as determined using four duplicate analyses of different sediment samples from the survey (Figure 3(f)), values were generally within 20% of each other or lower at higher concentrations.

Thus, these data indicate that the results reported here for mercury in sediments are accurate and precise.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. This was approximately the case for data (see below) for all of the sites for mercury, except NA-1. The data for the other sites are close enough that the discrepancies can be explained by analytical precision and the difficulty of ensuring that the samples are homogenized sufficiently.

Mercury in Sediments (µg/g)

Site	Calculated	Actual
MS-1	0.047	0.050
NA-1	0.067	0.080
MA-2	0.073	0.070
BB-10	0.090	0.082

Mercury concentrations measured in the sediments from these sites were similar to those measured in 1989 in Boundary Bay (Swain and Walton 1990b) and at the three Fraser River sites except Site NA-1, where the 1990 concentrations were higher than found in 1989 (Swain and Walton 1990a) using the same laboratory. The concentrations for the Fraser River sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present. The highest concentrations were at Site BB-10 which had less very fine particles than two of the three Fraser River sites. This may indicate a mercury contamination problem in Boundary Bay.

When the mean concentrations in the same particle size fraction are compared, an increase in mercury concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 0.048 µg/g at MS-1, to 0.073 µg/g at NA-1, and 0.075 µg/g at MA-2, while those for the smaller particles sized less than 0.063 mm were 0.045 µg/g, 0.067 µg/g, and 0.073 µg/g, respectively.

3.2.7.2 Mercury in Extract Samples

For the leachate extracts, the one analysis of a certified reference standard gave the identical result to the certified value, 0.0044 mg/L. Analytical precision, as determined using seven duplicate analyses of different extract samples from the survey, was very poor at the low levels measured in this survey. Values near the detection limit of 0.00005 mg/L were within a range of values from 17% to as high as 100% of each other.

This poor analytical precision would be part of the reason that the leachate extraction results in Table 3 could not be interpreted with respect to the concentration versus the particle size. With concentrations in the seawater blanks up to 0.00015 mg/L, only one extract from Site MA-2 for the smallest sized particles exceeded this concentration.

The actual release of mercury from sediments into the leachate on a mg/L for every µg/g mercury in the sediment for the two particle size classes is noted in Table 14. Values could only be calculated for Site MA-2 for one particle size, since concentrations in the leachate extracts for the other sites were above the maximum mercury concentration in the seawater blanks. The amount of mercury extracted from the sediment seemed high relative to concentrations of other metals.

3.2.8 NICKEL

3.2.8.1 Nickel in Sediments

For accuracy of nickel values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(j)), nickel values in sediments were generally within the certified range of values. In terms of analytical precision, as determined using four duplicate analyses of different sediment samples from the survey (Figure 3(g)), values were generally within 40% of each other or lower at higher concentrations.

Thus, these data indicate that the results reported here for nickel in sediments were accurate but not necessarily precise.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. This was approximately what was seen for all sites except Site MA-2 (see below). The data for the other sites are close enough that the discrepancies can be explained by analytical precision and the possibility that the samples were not homogenized sufficiently.

Nickel in Sediments (µg/g)

Site	Calculated	Actual
MS-1	45.9	43.4
NA-1	56.6	57.8
MA-2	69.4	52.1
BB-10	42.7	44.1

Nickel concentrations measured in the sediments from these sites were similar to those measured in 1989 in Boundary Bay (Swain and Walton 1990b) and in the three Fraser River sites except Site MS-1, where the 1990 concentrations were lower than found in 1989 (Swain and Walton 1990a) using the same laboratory. The concentrations for the Fraser River and Boundary Bay sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present.

When the mean concentrations in the same particle size fraction are compared, an increase in nickel concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 44.4 µg/g at MS-1, to 55.5 µg/g at NA-1, to 67.6 µg/g at MA-2, while those for the smaller sized particles less than 0.063 mm were 46.5 µg/g, 56.7 µg/g, and 70.4 µg/g, respectively.

3.2.8.2 Nickel in Extract Samples

For the extracts, the one analysis of a certified reference standard gave virtually the identical result to the certified value, 0.16 mg/L compared to 0.148 mg/L. Analytical precision, as determined using seven duplicate analyses of different extract samples from the survey, was very poor at the low levels measured in this survey. Values near the detection limit of 0.001 mg/L were as high as or greater than 100% of each other.

This poor analytical precision would be part of the reason that the leachate extraction results in Table 3 could not be interpreted with respect to the concentration versus the particle size. Nickel was not detected (<0.001 mg/L) in the seawater blanks, but was measurable in all the extracts (Table 3). This indicates that considerable quantities of nickel were being released using the modified leachate extraction procedure, and at approximately the predicted calculated concentration at Sites MS-1 and MA-2 (see below).

Nickel in Extracts (mg/L)

Site	Calculated	Actual
MS-1	0.0043	0.0050
NA-1	0.0096	0.0030
MA-2	0.0078	0.0070
BB-10	0.0045	0.0030

3.2.9 ZINC

3.2.9.1 Zinc in Sediments

For accuracy of zinc values in sediments, two different standard sediment types were analyzed. These were a marine sediment from the National Research Council of Canada and an estuarine sediment from the National Bureau of Standards (USA). In terms of accuracy (Figure 2(k)), zinc values in sediments were within the certified range of values at values of up to 175 µg/g, but higher than the true values above this concentration. However, all values measured in this survey were approximately the same or less than 175 µg/g, and would be considered accurate. In terms of analytical precision as determined using four duplicate analyses of different sediment samples from the survey (Figure 3(h)), values were generally within 10% of each other.

Thus, these data indicate that the results reported here for zinc in sediments are accurate and precise.

In theory, for any site, the value measured for the total sample should be about the same as the sum of the weighted results for the two particle sizes, taking into account analytical precision. This was not readily apparent for the data (see below) for any of the sites for zinc, although the percentage difference between actual and calculated was only from 2.2% at Site BB-10 to 13.9% at Site MA-2. This is likely due to analytical precision which is due in part to the difficulty of ensuring that the samples are homogenized sufficiently.

Zinc in Sediments (µg/g)

Site	Calculated	Actual
MS-1	67.2	72.0
NA-1	105.3	115
MA-2	159.5	140
BB-10	106.6	109

Zinc concentrations measured in the sediments from these sites were similar to those measured in 1989 in Boundary Bay (Swain and Walton 1990b) but at the three Fraser River sites the 1990 concentrations were lower than found in 1989 (Swain and Walton 1990a) using the same laboratory. The concentrations for the Fraser River and Boundary Bay sites seem to be related to the percentage of very fine particles present. The lowest concentrations were at MS-1, which had the smallest amount of very fine particles, while the highest concentrations were at NA-1, which had the highest amount of very fine particles present.

When the mean concentrations in the same particle size fraction are compared, an increase in zinc concentrations in a downstream direction appears to occur in the Fraser River. Values in the particle size fraction from 0.063 mm to 2 mm increased from 65.6 µg/g at MS-1, to 110 µg/g at NA-1, and 148 µg/g at MA-2, while those for the smaller sized particles less than 0.063 mm were 71.6 µg/g, 105 µg/g, and 163 µg/g, respectively.

3.2.9.2 Zinc in Extract Samples

For the extracts, the one analysis of a certified reference standard gave virtually the identical result to the certified value, 0.14 mg/L compared to 0.12 mg/L. Analytical precision, as determined using seven duplicate analyses of different extract samples from the survey, was normally not a problem in this survey since values were often less than detection (0.005 mg/L). However, some values which were detectable near the detection limit were not precise (60%)

This poor analytical precision would be part of the reason that the leachate extraction results in Table 3 could not be interpreted with respect to the concentration versus the particle size. Zinc could only be detected in extracts for the two sites (MA-2 and BB-10) with the highest concentrations in the sediments. Since all the seawater blank samples had non-detectable (<0.005 mg/L) zinc concentrations, it would appear that zinc could be released using the modified leachate extraction procedure above certain sediment concentrations of about 130 µg/g.

The actual release of zinc from sediments into the leachate on a mg/L for every µg/g zinc in the sediment for the two particle size classes is noted in Table 14. Values could only be calculated for Sites MA-2 and BB-10, since concentrations in the leachate extracts for the other sites were below detection (<0.005 mg/L). The amount of zinc extracted from the sediment at Site MA-2 for particles less than 0.063 mm was about the same as that found for particles between 0.063 mm and 2 mm in size.

3.2.10 CONCLUSIONS

The analytical results for metals in the sediments and the extracts were generally accurate in comparison to certified values. Exceptions to this, which were low, were cadmium and lead values in the extracts, and chromium in sediments. Arsenic values in sediments were both higher and lower than the certified range of values.

Analytical precision was generally good (within 20% of each other) for sediments and extracts. Exceptions were lead and nickel in sediments and copper, mercury, nickel, and zinc in leachate extracts.

The metal values measured in the different particle ranges were close enough to each other that it could not be determined for the sediments or the extracts whether there was a relationship between particle size and concentration. It is believed that this is due to the analytical precision being as large as any measured difference in value, as well as problems of having a homogeneous sample with the small volume of sediments used in the analytical determinations.

Metal concentrations in the sediments were generally the same magnitude as measured in 1989 at the same sites, except those from Site MS-1 were often lower in 1990. As well, when mean concentrations for the same particle size were compared for the Fraser River, increases in concentrations were noted in a downstream direction for all the metals. This may indicate that when comparing data for systems with very different particle size gradations among sites, that more meaningful data on sediments can be obtained by measuring concentrations in the same particle size range than in the total sediment sample.

The modified leachate extraction procedure released the following metals from sediments: cadmium, copper, and nickel at all the sites; and arsenic at Site BB-10 and zinc at Site BB-10 and MA-2.

On the basis of the concentration of each metal in the leachate extract compared to the amount of that metal in the original sediment sample, preliminary results indicate that the preferential order of release of metals was cadmium, arsenic, mercury, nickel, copper, and zinc. There was no apparent trend for one class of particles to release more metals than the other class.

3.3 CHLORINATED PHENOLS AND PCBs

3.3.1 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance of chlorophenols and PCBs for both sediments and leachate extractions involved checking for contamination following extraction, using spiked samples to determine percent recoveries, and performing duplicate analyses. For the check on contamination in the extraction procedure, five extracts and four sediment samples were used, while for checking for the percent recovery four extract and sediment samples were used. Contamination was not found in any samples for leachate extractions or sediments.

The following are the percent recoveries of spiked samples at concentrations of 0.020 mg/L for extracts (twenty times the detection limit) and 0.01 µg/g for sediments (detection limit for PCBs and twice the detection limit for chlorophenols).

Percent Recoveries (%)

	SEDIMENTS		EXTRACTS	
	Range	Mean	Range	Mean
trichlorophenol	62-75	67.5	66-86	77
tetrachlorophenol	50-71	64.8	76-107	85.5
pentachlorophenol	62-95	83.0	72-94	85.3
PCBs	66-82	72.8	68-91	79.5

The spiked samples consist of the organic in question being put into a solvent, and indicate possible losses in the analytical process past the point of extraction. Due to the artificial nature of this quality control process, losses which exist for the spike do not necessarily occur in the analysis of the actual sample. Therefore the percent recoveries likely indicate a "worst-case" scenario. For this reason, no corrections have been applied to the data.

Four duplicate sediment analyses and seven duplicate extract analyses were performed. All duplicates were below the detection limits of 0.005 µg/g for each of the chlorophenols and 0.010 µg/g for PCBs in sediments and 0.001 mg/L in the extracts.

3.3.2 MEASURED VALUES

Chlorophenol and PCB concentrations were all below the detection limits noted above for both sediments (Table 4) and the leachate extractions (Table 5). This is the same result as was found in 1989 at the same sites in the Fraser River (Swain and Walton 1990a) although PCBs were measured in one sample from Boundary Bay in 1989 (Swain and Walton 1990b).

3.3.3 CONCLUSIONS

Chlorophenols and PCBs were not detectable in the sediment or leachate extractions. Concentrations in the sediments were about the same as measured in 1989.

3.4 POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)

3.4.1 QUALITY ASSURANCE / QUALITY CONTROL

PAHs are commercially-used compounds, are naturally present in coal and petroleum, and are also formed during the incomplete combustion of hydrocarbons (Garrett 1982).

Quality assurance of PAHs involved checking for contamination following extraction using four sediment and five leachate extract samples, and checking the percent recovery of the four sediment and five leachate extract samples. Contamination was not detected in any of the extraction blanks.

The spiked samples consist of the organic in question being put into a solvent, and indicate possible losses in the analytical process past the point of extraction. Due to the artificial nature of this quality control process, losses which exist for the spike do not necessarily occur in the analysis of the actual sample. Therefore the percent recoveries likely indicate a "worst-case" scenario. For this reason, no corrections have been applied to the data. Percent recoveries for spiked samples at concentrations of 0.020 and 0.001 mg/L for the leachate extractions and 0.4 µg/g for the sediments were as follows:

	Sediments %		Leachate extractions %	
PAH	RANGE	MEAN	RANGE	MEAN
ACENAPHTHENE	49-78	69	93-108	100.5
ACENAPHTHYLENE	60-80	72.8	105-115	109
ANTHRACENE	83-89	85	82-113	93
BENZO(A) ANTHRACENE	81-93	89	66-120	90
BENZO(A) PYRENE	75-91	86.8	58-113	81.3
BENZO(B) FLUORANTHENE	77-94	88.3	54-115	81.5
BENZO(GHI) PERYLENE	72-93	85.8	52-102	74.3
BENZO(K) FLUORANTHENE	74-91	85.8	50-126	87.3
CHRYSENE	80-93	88.5	82-123	98
DIBENZO (AH) ANTHRACENE	73-101	72.5	30-112	68.8
FLUORANTHENE	82-95	89.3	90-122	100.5
FLUORENE	79-84	80.8	95-122	104.3
INDENO (1,2,3-CD) PYRENE	77-95	88	53-108	78
NAPHTHALENE	61-76	68.3	88-120	101.3
PHENANTHRENE	80-89	85.8	94-114	102.5
PYRENE	81-97	89	90-120	101.3

For PAHs in sediments, some differences existed for some PAHs in some samples. The following duplicate analyses are only for detectable analyses since many of the four duplicates were less than the detection limit. The values listed under the title "Duplicate" for individual PAHs, in order to present a more concise picture, are not necessarily all for the same sample.

PAH	DUPLICATE µg/g		DUPLICATE µg/g		DUPLICATE µg/g	
ACENAPHTHENE	0.005	<0.005	0.005	<0.005		
ACENAPHTHYLENE	0.009	0.010				
ANTHRACENE	0.013	0.025	0.006	0.005	0.023	0.024
BENZO(A) ANTHRACENE	0.012	0.014	0.010	<0.010	0.063	0.052
BENZO(A) PYRENE	0.057	0.053				
BENZO(B) FLUORANTHENE	0.023	<0.020	0.085	0.076		
BENZO(GHI) PERYLENE	0.041	0.044				
BENZO(K) FLUORANTHENE	0.039	0.033				
CHRYSENE	0.016	0.024	0.015	0.014	0.076	0.058
FLUORANTHENE	0.047	0.055	0.028	0.024	0.12	0.13
FLUORENE	0.007	0.009	0.007	0.006	0.015	0.013
INDENO (1,2,3-CD) PYRENE	0.041	0.030				
NAPHTHALENE	0.007	<0.005	0.010	0.007		
PHENANTHRENE	0.034	0.033	0.022	0.019	0.075	0.086
PYRENE	0.040	0.047	0.028	0.024	0.13	0.13

These data indicate that, with the odd exception, the precision of the PAH measurements generally is good, i.e., within 20% of each other. The exceptions are one measurement for anthracene, fluorene, indeno (1,2,3-cd) pyrene, and two measurements for chrysene and naphthalene.

3.4.2 MEASURED VALUES

Data for the PAHs in sediments are summarized in Table 6, while those for leachate extractions are summarized in Table 7. PAHs were not detected (<0.001 mg/L) in any of the leachate extractions.

In the sediment samples, individual PAHs were not detected (<0.02 µg/g) for any samples for dibenzo (a,h) anthracene, while the other individual PAHs were detected in varying numbers of samples, but most frequently at the offshore site (BB-10) in Boundary Bay and the Ewen Slough site (MA-2) in the Main Arm.

The following discussion will focus on those PAHs where the detectable concentrations approached the Water Quality Objectives for PAHs in sediments of Burrard Inlet (Nijman and Swain 1990) which are usually about 10% of the lowest AET value for Puget Sound. With this in mind, only the maximum fluoranthene concentration of 0.18 µg/g at the North Arm site (NA-1) exceeded the Burrard Inlet objective of 0.17 µg/g. The Water Quality Objective was based on being one-tenth the Puget Sound AET.

As was the case for most of the metals, when sufficient detectable PAH data were available, it always was often possible to determine a correlation between the different particle ranges and the PAH concentration. A summary of calculated and measured PAH values is shown below based on the percentage of each particle size and the chemistry data for those sizes.

PAHs in Sediments (µg/g)

	Anthracene		Benzo(a) anthracene		Benzo (a) pyrene	
Site	Calculated	Actual	Calculated	Actual	Calculated	Actual
NA-1	0.007	0.015	0.012	0.024		
MA-2	0.013	0.006	0.014	0.011		
BB-10	0.015	0.016	0.045	0.033	0.047	0.032

	Benzo(b) fluoranthene		Benzo(g,h,i) perylene		Benzo(k) fluoranthene	
Site	Calculated	Actual	Calculated	Actual	Calculated	Actual
BB-10	0.067	0.053	0.027	0.026	0.032	0.023

	Chrysene		Fluoranthene		Fluorene	
Site	Calculated	Actual	Calculated	Actual	Calculated	Actual
NA-1	0.018	0.028	0.036	0.116	0.008	0.014
MA-2	0.023	0.018	0.046	0.026	0.008	0.006
BB-10	0.051	0.042	0.088	0.094	0.008	0.008

	Naphthalene		Phenanthrene		Pyrene	
Site	Calculated	Actual	Calculated	Actual	Calculated	Actual
NA-1			0.028	0.053	0.038	0.096
MA-2	0.007	0.009	0.030	0.021	0.042	0.024
BB-10	0.007	0.008	0.049	0.047	0.088	0.102

There is no real trend consistent for these data, with some actual values being larger than the calculated while some were smaller, and some calculations being very close to actual (e.g., anthracene at Site BB-10) and others not very close (e.g., anthracene at NA-1).

In comparison to PAHs measured at the same sites in 1989 (Swain and Walton 1989(a,b)), 1990 maximum concentrations were lower than maximum 1989 concentrations except for the following which were higher in 1990: anthracene at Site BB-10; benzo(a)anthracene and phenanthrene at Site MS-1; benzo(a)pyrene at Sites MA-2 and BB-10; benzo(b)fluoranthene at the three Fraser River sites; chrysene at Sites NA-1, MA-2, and BB-10; fluoranthene at Sites MS-1 and NA-1; fluorene at Sites NA-1 and MA-2; naphthalene at Sites NA-1 and BB-10; and pyrene at Site MA-2.

When the mean concentrations in the same particle size fraction are compared, an increase in PAH concentrations in a downstream direction appears to occur in the Fraser River. Values in both the particle size fractions from 0.063 mm to 2 mm and less than 0.063 mm increased from Site MS-1 to NA-1 and MA-2. This trend was apparent for mean concentrations of anthracene, benzo(a)anthracene, benzo(b)fluoranthene, chrysene, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene.

3.4.3 CONCLUSIONS

PAHs were not released from the sediments using the modified leachate extraction procedure. This means that PAHs likely would not be responsible for any toxicity which may be determined for these sediments. When compared to earlier data for the same sites, maximum concentrations for some PAHs were lower while for others were higher. There did not appear to be a good correlation between actual and calculated predicted values for the sediments. The mean concentrations of a number of individual PAHs for the same particle sizes increased in a downstream direction in the Fraser River.

3.5 ORGANOCHLORINE PESTICIDES

Organochlorine pesticides measured in this survey were aldrin, alpha-chlordane, gamma-chlordane, dieldrin, DDT, DDE, DDD, endrin, endosulfan-I, endosulfan-II, endosulfan sulfate, heptachlor, heptachlor epoxide, lindane, methoxychlor, and toxaphene.

3.5.1 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance for organochlorine pesticides involved checking for contamination following extraction with four blank samples in sediments and five blank samples for leachate extractions. As well, the percent recovery for spiked samples was checked with three samples for the leachate extractions and four samples for the sediments.

Organochlorine pesticides were not detected in any of the extraction blanks for either sediments or the leachate extractions. The spiked samples do not necessarily indicate losses that would occur in the analyses. The results in the Tables have had no corrections made for the recovery data. Percent recoveries for the spiked samples at concentrations of 0.007 µg/g for sediments and 0.0002 mg/L for the leachate extractions were as follows:

Percent Recoveries

Organochlorine	Sediment		Leachate Extractions	
Pesticide	Range	Mean	Range	Mean
Aldrin	74-82	77.5	95-116	107
Alpha-Chlordane	74-100	84.8	104-124	112.3
Gamma-Chlordane	81-89	86.8	105-124	112
Dieldrin	66-107	94	89-127	107
DDT	105-187	126	82-110	98.3
DDD	86-110	98.5	107-124	113.7
DDE	85-110	99	98-128	112
Endrin	84-110	98	73-131	97.3
Endosulfan I	85-106	93.8	105-129	113.7
Endosulfan II	82-96	87.5	68-112	96.7
Endosulfan Sulphate	59-107	86.3	92-109	98
Heptachlor	82-107	88.8	85-114	99.7
Heptachlor Epoxide	88-99	92.8	92-110	102.3
Lindane	64-94	78.5	76-109	94.3
Methoxychlor	92-116	105	93-108	101.7

3.5.2 MEASURED VALUES

Data for the organochlorine pesticides in sediments are summarized in Table 8, while those for the leachate extractions are in Table 9. None of the organochlorine pesticides could be detected in either sediments or extracts in any of the particle sizes. This means that any toxicity which may occur likely would not be due to the presence of organochlorine pesticides.

3.5.3 CONCLUSIONS

Organochlorine pesticides could not be detected in either sediments or extracts. Any toxicity which may occur likely would not be due to the presence of organochlorine pesticides.

3.6 GUAIACOLS AND CATECHOLS

Guaiacols and catechols are compounds that are extracted from wood during the pulping and bleaching process. The bleaching process creates chloroguaiacols and chlorocatechols. Chloroguaiacols are known to accumulate in livers of exposed organisms.

3.6.1 QUALITY ASSURANCE / QUALITY CONTROL

Quality assurance for guaiacols and catechols involved checking for contamination following extraction with two blank samples in sediments. As well, the percent recovery for spiked samples was checked with two samples.

Guaiacols and catechols were not detected in either of the extraction blanks (<0.001 µg/g). The spiked samples do not necessarily indicate losses that would occur in the analyses. The results in the Tables have had no corrections made for the recovery data. Percent recoveries for the spiked samples at concentrations of 0.004 µg/g for sediments were as follows:

Guaiacol/Catechol	Spike #1	Spike #2
2,4,5-trichloroguaiacol	82%	95%
tetrachloroguaiacol	91%	120%
3,4,5-trichlorocatechol	65%	55%
Tetrachlorocatechol	63%	59%

3.6.2 MEASURED VALUES

Guaiacols and catechols were measured in triplicate only in the total sediment samples from each of the four sites since there were insufficient funds to do these tests in all particle size fractions. Tetrachlorocatechol and 3,4,5-trichlorocatechol were not detected (<0.001 µg/g) in any of the samples from any of the sites. Tetrachloroguaiacol and 2,4,5-trichloroguaiacol were above detection in sediments from the North and Main arms (NA-1 and MA-2, respectively). The fact that sediments from these two sites had in the order of three to four times the quantity of small particles leads us to believe that the guaiacols are associated with the finer sized fraction.

Tetrachloroguaiacol and 2,4,5-trichloroguaiacol were not detected in Boundary Bay at BB-10.

3.6.3 CONCLUSIONS

Tetrachlorocatechol and 3,4,5-trichlorocatechol were not in measurable concentrations at any of the sites, while tetrachloroguaiacol and 2,4,5-trichloroguaiacol were only found at the two sites in the Main and North arms.

3.7 POLYCHLORINATED DIOXINS AND FURANS

Dioxins and furans have similar chemical structures, biological effects, and toxic responses. Dioxins are a family of 75 related chemical compounds, while furans are a family of 135 related compounds. The most toxic dioxin is 2,3,7,8-TCDD, a tetrachlorinated dioxin. Other forms of dioxins are from 10 to 10 000 times less toxic. Furans are from 2 to 10 000 times less toxic than 2,3,7,8-TCDD.

3.7.1 QUALITY ASSURANCE / QUALITY CONTROL

Dioxins and furans were checked by calculating the surrogate standard recovery for five dioxins and one furan. All samples were spiked with an aliquot of ^{13}C labelled internal standard solution prior to the analysis. Surrogate standard recoveries for the three replicate samples from each site were as follows:

Percent Recoveries

SURROGATE	MS-1	NA-1	MA-2	BB-10
$^{13}C\text{-}T_4CDD$	76,111,94	94,79,87	44,70,63	40,44,81
$^{13}C\text{-}T_4CDF$	87,117,101	98,88,94	46,69,64	40,40,90
$^{13}C\text{-}P_5CDD$	99,111,97	108,87,91	55,80,73	59,53,99
$^{13}C\text{-}H_6CDD$	70,99,88	78,66,79	43,63,56	34,40,71
$^{13}C\text{-}H_7CDD$	69,95,89	75,65,77	47,69,58	45,49,72
$^{13}C\text{-}O_8CDD$	44,74,69	50,39,56	34,55,43	25,46,53

These data indicate that the recoveries vary with the site sampled; however, there is no apparent correlation to the particle size at the sites since the finest sized particles were at NA-1 and the largest sized particles at MS-1. The best percent recoveries were always found at these sites. The lowest recoveries were always at Sites MA-2 and BB-10.

3.7.2 MEASURED VALUES

The detection limit reported by the laboratory varied with each sample analyzed. Therefore it was possible to have a value of <1.3 pg/g for one replicate and a second replicate value of 0.8 pg/g for the same site. No special treatment was applied to these types of data in the preparation of the statistics in Tables 11 and 12.

Detectable dioxin concentrations were almost always found for at least one replicate sample from the North Arm Site NA-1, the site with the smallest sized particles. The highest concentrations measured at Site NA-1 were 60 pg/g of H_6CDD and 86 pg/g of H_7CDD. Mah et. al. (1989) reported undetectable concentrations of dioxins in the sediments of the Fraser River upstream from Prince George; however, the detection limits were based on a 5 gram sample (compared to about 15 gram sample used in this study) and were about 10 times higher than used for our study. Regardless, the H_6CDD and H_7CDD concentrations found in this study at NA-1 exceeded the levels of detection for these dioxins in the study of Mah et. al. (1989). H_6CDD and H_7CDD have toxicity equivalency factors of 0.1 and 0.01, respectively, compared to the most toxic form of dioxin, 2,3,7,8-tetrachlorodibenzodioxin (Environment Canada and Health and Welfare Canada 1990).

The most commonly detected dioxins at all four sites with the highest concentrations were H_7CDD and O_8CDD, with equivalency factors of 0.01 and 0.0001, respectively. Thus, the importance of these apparently high concentrations is diminished when examined relative to 2,3,7,8-tetrachlorodibenzodioxin (Environment Canada and Health and Welfare Canada 1990).

Furans were not detected at Site MS-1, the site with the largest sediment particle size (Tables 1 and 12). With one exception (total P_5CDF at Site MA-2), when a particular furan was detected at one of the other three sites, it was detected at all three sites. Of the ten most toxic furans identified (Environment Canada and Health and Welfare Canada 1990), only three were at detectable concentrations in this survey. These were 2,3,7,8-T_4CDF, 1,2,3,4,6,7,8-H_7CDF, and O_8CDF with equivalency factors of 0.5, 0.01, and 0.0001, respectively.

Mah *et*. *al*. (1989) reported undetectable concentrations of furans in the sediments of the Fraser River upstream from Prince George; however, the detection limits were based on a 5 gram sample (compared to about 15 gram sample used in this study) and were about 10 times higher than used for our study. Regardless, the 2,3,7,8-T_4CDF concentrations detected in this study (but not the 1,2,3,4,6,7,8-H_7CDF or the O_8CDF concentrations) would also have been detected by the analysis reported in Mah *et*. *al*. (1989).

3.7.3 CONCLUSIONS

Some forms of dioxins and one furan measured in the sediments were above concentrations measured in the Fraser River upstream from Prince George, a site which would be considered not to be impacted significantly by human activity. It is possible that dioxins and furans therefore may be responsible for toxicity which may be present; however, this is uncertain because leachate extractions were not examined for the presence of dioxins and furans.

3.8 TOXICITY TESTING

Toxicity tests were performed on the leachate extractions using both the microtox bioluminescence test (EC50) and the Sand Dollar (*Denaster excentricus*) test (FID50). Triplicate tests were performed for each site, the leachate extract for each having been prepared from a separate sub-sample from that site.

3.8.1 QUALITY ASSURANCE / QUALITY CONTROL

QA/QC measures used for this testing were to perform the two types of bioassays on leachate extractions from two separate sub-samples, as well as to run the tests on a sample blank. Only one sample blank was performed, while seven split extracts were tested.

The blank sample was non-toxic using both bioassay test procedures. The seven microtox bioluminescence duplicates were non-toxic, while six of the seven sand dollar (Denaster excentricus) duplicates were non-toxic. The seventh sand dollar duplicate had values of 12.49% and 5.37%. This difference is likely acceptable considering the leachate extractions were from two different sub-samples.

3.8.2 MEASURED VALUES

The data for the toxicity testing are summarized for microtox bioluminescence in Table 13 and for sand dollar (Denaster excentricus) bioassays in Table 14. The leachate extractions were non-toxic for all replicates for all particle sizes at all four sites. The leachate extractions were non-toxic for all replicates for all the particle sizes at three of four sites. The fourth site, Site BB-10 in Boundary Bay exhibited some toxicity in two of the three replicate samples for the smallest sized particles, and some toxicity in one of the three replicate samples for the larger sized particles. For all three replicate samples, the extract associated with the total sample at Site BB-10 was not toxic.

Levels of guaiacols, catechols, dioxins, and furans were usually higher at the other sites than at the Boundary Bay site. Therefore, it is unlikely that guaiacols, catechols, dioxins, or furans are responsible for the apparent toxicity at Site BB-10. For the other characteristics examined in this study, measurements were made of concentrations in the leachate extractions, so that a direct measure of potential toxicity is apparent.

The results for the leachate extractions for PAHs, PCBs, chlorophenols, and organochlorine pesticides were all less than detection. Relative to the mean concentrations at the other three sites, mean concentrations (Table 3) of only arsenic, copper, and molybdenum were high in the extract from Site BB-10. In fact, only mean molybdenum concentrations in the extract were higher than values recorded for any of the extracts. Ironically, the mean molybdenum concentrations actually decreased with decreasing particle size, opposite to what would be expected if molybdenum were responsible for the toxicity. Therefore, it is not readily apparent what caused this toxicity at Site BB-10 although synergistic effects of arsenic and copper cannot be dismissed.

The actual sediment chemistry for the two particle size fractions at BB-10 which illustrated a toxic effect had the highest mean concentrations of arsenic, copper, lead, and mercury, as well as several PAHs (acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene). Any or all of these compounds individually or in combination may be responsible for the toxic effects noted.

3.8.3 CONCLUSIONS

The sediments from all sites except Site BB-10 in Boundary Bay were non-toxic, as indicated using the microtox bioluminescence test and the sand dollar (Denaster excentricus) test procedures. At Site BB-10, toxicity was noted using only the sand dollar test, and only in 2 of the 3 replicates for the finer sized particles and in one of the three replicates for the larger sized particles. There was no apparent reason for the toxicity, based upon an analysis of the chemical testing on both the sediments and the extracts used for the test procedures. However, the chemistry data do point to the possibility of a number of metals and PAHs associated with the particle size fractions having the potential to cause the toxicity.

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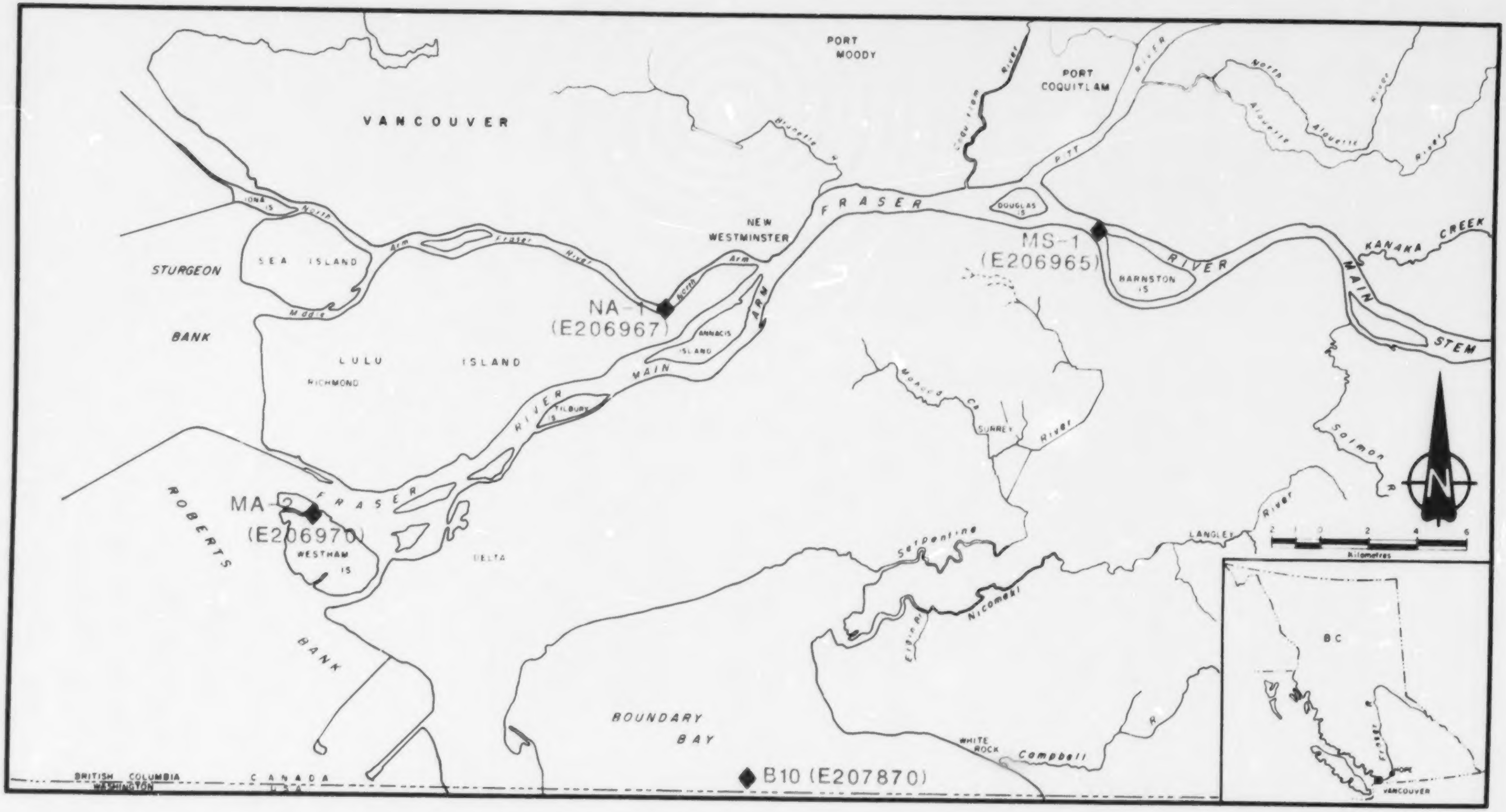
VANCOUVER
PORT MOODY
PORT COQUITLAM
NEW WESTMINSTER
FRASER RIVER
MAIN STEM
KANAKA CREEK
North Alouette River
Alouette River
Pitt River
Coquitlam River
Brunette R.
DOUGLAS IS
BARNSTON IS
MS-1
(E206965)
NA-1
(E206967)
North Arm Fraser River
Middle Arm
IONA IS
SEA ISLAND
STURGEON BANK
LULU ISLAND
RICHMOND
ANNACIS ISLAND
MAIN ARM
MAIN RIVER
TILBURY IS
FRASER
MA-2
(E206970)
WESTHAM IS
DELTA
ROBERTS BANK
BOUNDARY BAY
B10 (E207870)
Nicomekl
Serpentine
Elgin R.
Campbell R.
WHITE ROCK
SURREY
Mahood Cr.
River
Salmon R.
LANGLEY
River
Kilometres
2 1 0 2 4 6
N
BC
Fraser R.
HOPE
VANCOUVER
BRITISH COLUMBIA
WASHINGTON
CANADA
U.S.A.

FIGURE 1 LOCATIONS OF 1990 SEDIMENT SAMPLES

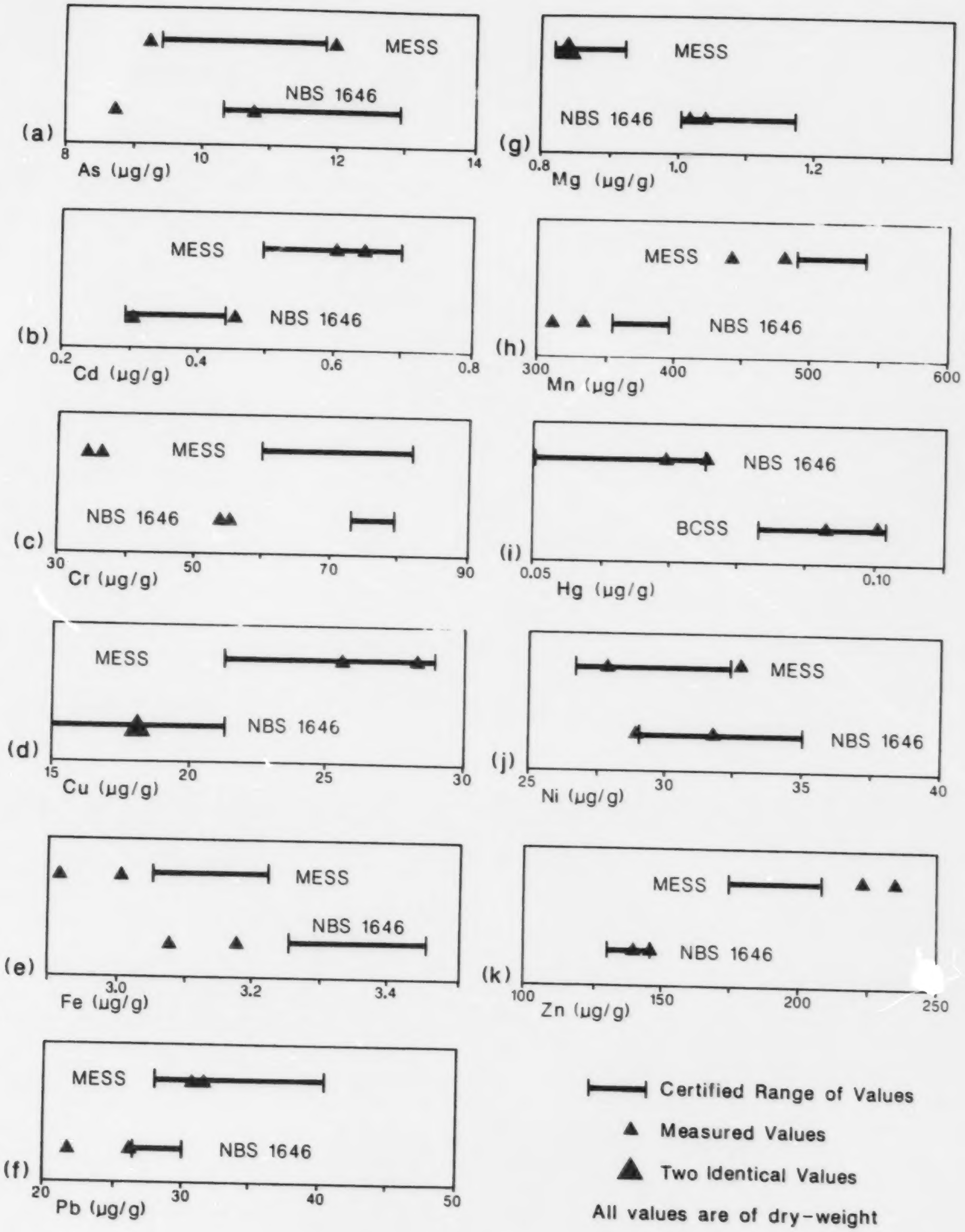

FIGURE 2 ACCURACY DATA FOR SEDIMENTS - 1990 SURVEY

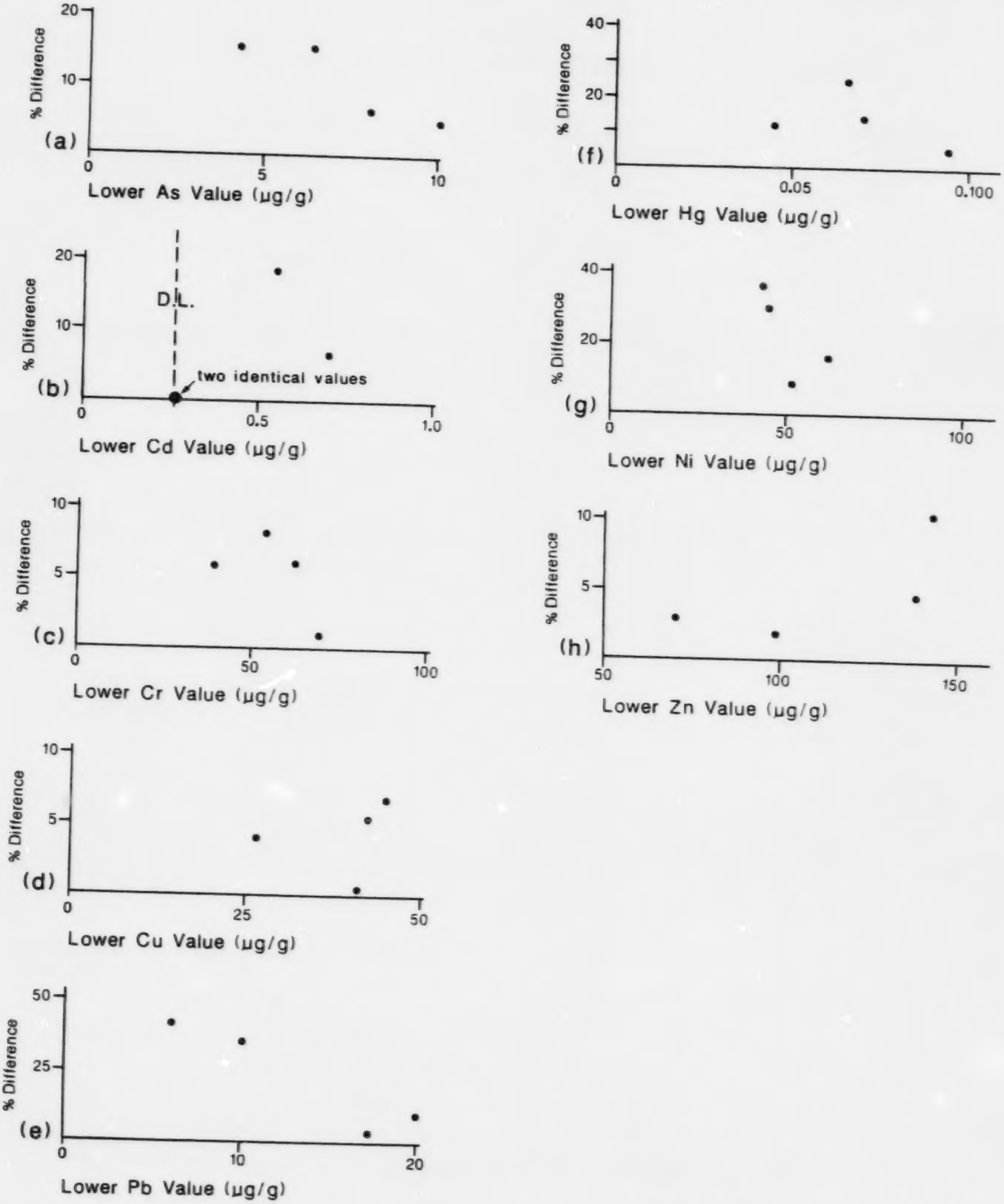

FIGURE 3 ANALYTICAL PRECISION FOR DUPLICATE SEDIMENT ANALYSES 1990 SURVEY

TABLE 1
SUMMARY OF PHYSICAL CHARACTERISTICS OF SEDIMENTS*

		(% dry-weight)		
CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STD. DEV.
PARTICLE SIZE				
SITE MS-1 : >2mm	0.0	0.0	0.0	0.0
:0.063-2mm	86.7	55.9	74.2	16.2
: <0.063 mm	44.1	13.3	25.8	16.2
SITE NA-1 : >2mm	0.0	0.0	0.0	0.0
:0.063-2mm	13.3	1.3	5.8	6.54
: <0.063 mm	98.7	86.7	94.2	6.54
SITE MA-2 : >2mm	1.0	0.5	0.7	0.26
:0.063-2mm	19.8	12.6	16.0	4.00
: <0.063 mm	86.4	79.6	83.3	3.45
SITE BB-10: >2mm	0.0	0.0	0.0	0.00
:0.063-2mm	63.9	36.6	47.7	14.4
: <0.063 mm	63.7	36.1	52.3	14.4
TOTAL ORGANIC CARBON				
SITE MS-1	0.30	0.27	0.28	0.015
SITE NA-1	0.99	0.75	0.88	0.12
SITE MA-2	1.09	0.97	1.04	0.061
SITE BB-10	1.24	0.67	0.97	0.286
TOTAL INORGANIC CARBON				
SITE MS-1	0.37	0.23	0.29	0.072
SITE NA-1	0.46	0.32	0.40	0.072
SITE MA-2	0.47	0.40	0.44	0.036
SITE BB-10	0.45	0.29	0.39	0.085

TABLE 1 (CONTINUED)

		(% dry-weight)		
CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STD. DEV.
TOTAL VOLATILE RESIDUE				
SITE MS-1	1.7	1.3	1.5	0.20
SITE NA-1	3.3	3.0	3.2	0.17
SITE MA-2	4.4	3.5	3.9	0.46
SITE BB-10	5.0	4.3	4.8	0.40

* 3 SAMPLES FOR EACH SITE AND FOR EACH PARTICLE SIZE, WHERE APPLICABLE.

TABLE 2
SUMMARY OF METALS IN SEDIMENTS *

METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
		(µg/g dry-weight)		
ARSENIC				
SITE MS-1 : total	6.00	4.55	5.03	0.88
:0.063-2mm	4.50	2.05	3.77	0.78
: <0.063 mm	4.90	3.75	4.27	0.58
SITE NA-1 : total	7.50	7.00	7.17	0.29
:0.063-2mm	7.50	6.50	6.83	0.58
: <0.063 mm	8.00	6.50	7.33	0.76
SITE MA-2 : total	7.50	6.00	6.50	0.87
:0.063-2mm	9.00	8.00	8.50	0.50
: <0.063 mm	8.00	7.50	7.83	0.29
SITE BB-10 : total	13.0	10.5	11.5	1.32
:0.063-2mm	10.5	10.0	10.2	0.29
: <0.063 mm	10.5	9.5	9.83	0.58
CADMIUM				
SITE MS-1 : total	<0.25	<0.25	<0.25	-
:0.063-2mm	0.35	<0.25	<0.25+	-
: <0.063 mm	0.25	<0.25	<0.25+	-
SITE NA-1 : total	<0.25	<0.25	<0.25	-
:0.063-2mm	0.30	<0.25	<0.25+	-
: <0.063 mm	<0.25	<0.25	<0.25	-
SITE MA-2 : total	0.30	0.25	0.27	0.03
:0.063-2mm	0.65	0.45	0.55	0.10
: <0.063 mm	0.60	0.55	0.58	0.03
SITE BB-10 : total	0.95	0.75	0.87	0.10
:0.063-2mm	0.75	0.60	0.68	0.08
: <0.063 mm	0.80	0.65	0.72	0.08

TABLE 2 (CONTINUED)

		(µg/g dry-weight)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
CHROMIUM				
SITE MS-1 : total	57.0	33.2	43.3	12.3
:0.063-2mm	59.7	37.1	45.3	12.5
: <0.063 mm	47.9	39.2	44.7	4.81
SITE NA-1 : total	65.1	50.6	59.8	7.97
:0.063-2mm	61.8	56.8	59.4	2.51
: <0.063 mm	63.2	58.4	60.1	2.72
SITE MA-2 : total	57.8	49.7	54.8	4.46
:0.063-2mm	65.2	55.0	61.1	5.40
: <0.063 mm	71.6	63.8	68.9	4.42
SITE BB-10 : total	79.8	47.6	60.4	17.1
:0.063-2mm	70.4	66.7	68.8	1.90
: <0.063 mm	62.7	48.0	53.3	8.14
COPPER				
SITE MS-1 : total	31.4	22.4	26.1	4.69
:0.063-2mm	32.8	20.9	25.1	6.65
: <0.063 mm	29.3	27.1	27.9	1.22
SITE NA-1 : total	47.8	43.5	45.8	2.17
:0.063-2mm	46.2	42.1	44.7	2.26
: <0.063 mm	46.0	41.2	43.2	2.48
SITE MA-2 : total	42.0	39.0	40.5	1.50
:0.063-2mm	48.0	46.5	47.4	0.81
: <0.063 mm	51.5	47.4	49.9	2.17
SITE BB-10 : total	45.1	27.0	35.5	9.10
:0.063-2mm	44.5	39.4	42.5	2.74
: <0.063 mm	28.0	25.4	26.4	1.40

TABLE 2 (CONTINUED)

		(µg/g dry-weight)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
IRON				
SITE MS-1 : total	3.56	2.39	2.88	0.61
:0.063-2mm	3.42	2.33	2.71	0.62
: <0.063 mm	3.28	2.69	2.94	0.31
SITE NA-1 : total	4.30	3.86	4.11	0.23
:0.063-2mm	3.85	3.67	3.78	0.09
: <0.063 mm	3.71	3.44	3.61	0.15
SITE MA-2 : total	3.85	3.44	3.68	0.21
:0.063-2mm	4.65	4.08	4.38	0.29
: <0.063 mm	4.84	4.53	4.63	0.18
SITE BB-10 : total	4.26	2.63	3.37	0.83
:0.063-2mm	4.51	3.96	4.28	0.30
: <0.063 mm	2.94	2.69	2.79	0.13
LEAD				
SITE MS-1 : total	4.50	3.50	3.83	0.58
:0.063-2mm	5.50	3.50	4.33	1.04
: <0.063 mm	14.5	6.00	9.00	4.77
SITE NA-1 : total	15.0	4.50	8.83	5.48
:0.063-2mm	10.5	7.00	9.00	1.80
: <0.063 mm	13.5	11.0	12.5	1.32
SITE MA-2 : total	14.5	12.5	13.2	1.15
:0.063-2mm	18.0	13.0	15.3	2.52
: <0.063 mm	15.5	14.0	14.7	0.76
SITE BB-10 : total	23.0	15.0	18.8	4.01
:0.063-2mm	26.5	22.0	24.3	2.25
: <0.063 mm	18.0	14.0	18.8	7.94

TABLE 2 (CONTINUED)

		(µg/g dry-weight)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
MAGNESIUM				
SITE MS-1 : total	1.21	0.95	1.06	0.13
:0.063-2mm	1.16	0.93	1.03	0.12
: <0.063 mm	1.16	1.11	1.13	0.03
SITE NA-1 : total	1.55	1.42	1.49	0.07
:0.063-2mm	1.51	1.41	1.46	0.05
: <0.063 mm	1.46	1.37	1.43	0.05
SITE MA-2 : total	1.39	1.26	1.32	0.07
:0.063-2mm	1.49	1.38	1.45	0.06
: <0.063 mm	1.62	1.49	1.55	0.07
SITE BB-10 : total	1.72	1.01	1.33	0.36
:0.063-2mm	1.67	1.47	1.59	0.11
: <0.063 mm	1.15	1.02	1.07	0.07
MANGANESE				
SITE MS-1 : total	633	443	526	97.4
:0.063-2mm	592	433	497	83.9
: <0.063 mm	563	544	556	10.4
SITE NA-1 : total	1090	939	1003	78.1
:0.063-2mm	675	609	647	34.3
: <0.063 mm	718	656	685	26.2
SITE MA-2 : total	654	611	626	24.3
:0.063-2mm	804	762	784	21.1
: <0.063 mm	888	800	842	44.1
SITE BB-10 : total	467	318	384	75.9
:0.063-2mm	427	371	408	31.8
:< 0.063 mm	353	327	342	13.6

TABLE 2 (CONTINUED)

		(µg/g dry-weight)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
MERCURY				
SITE MS-1 : total	0.065	0.040	0.050	0.013
:0.063-2mm	0.075	0.035	0.048	0.023
: <0.063 mm	0.045	0.045	0.045	0.000
SITE NA-1 : total	0.090	0.075	0.080	0.009
:0.063-2mm	0.080	0.070	0.073	0.006
: <0.063 mm	0.070	0.065	0.067	0.003
SITE MA-2 : total	0.070	0.070	0.070	0.000
:0.063-2mm	0.080	0.070	0.075	0.005
: <0.063 mm	0.075	0.070	0.073	0.003
SITE BB-10 : total	0.090	0.075	0.082	0.008
:0.063-2mm	0.120	0.095	0.105	0.013
: <0.063 mm	0.080	0.070	0.077	0.006
MOLYBDENUM				
SITE MS-1 : total	<1.5	<1.5	<1.5	-
:0.063-2mm	<1.5	<1.5	<1.5	-
: <0.063 mm	<1.5	<1.5	<1.5	-
SITE NA-1 : total	<1.5	<1.5	<1.5	-
:0.063-2mm	<1.5	<1.5	<1.5	-
: <0.063 mm	<1.5	<1.5	<1.5	-
SITE MA-2 : total	<1.5	<1.5	<1.5	-
:0.063-2mm	<1.5	<1.5	<1.5	-
: <0.063 mm	<1.5	<1.5	<1.5	-
SITE BB-10 : total	<1.5	<1.5	<1.5	-
:0.063-2mm	<1.5	<1.5	<1.5	-
: <0.063 mm	<1.5	<1.5	<1.5	-

TABLE 2 (CONTINUED)

		(µg/g dry-weight)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
NICKEL				
SITE MS-1 : total	46.2	40.8	43.4	6.60
:0.063-2mm	50.8	36.7	44.4	7.13
: <0.063 mm	51.3	43.8	46.5	4.17
SITE NA-1 : total	60.7	53.2	57.8	7.60
:0.063-2mm	57.3	53.2	55.5	2.10
: <0.063 mm	59.6	54.9	56.7	2.56
SITE MA-2 : total	53.2	49.9	52.1	1.91
:0.063-2mm	72.2	63.1	67.6	4.55
: <0.063 mm	73.5	66.3	70.4	3.69
SITE BB-10 : total	55.2	37.3	44.1	9.69
:0.063-2mm	58.1	48.3	53.1	4.90
: <0.063 mm	34.0	31.7	33.2	1.33
ZINC				
SITE MS-1 : total	79.4	61.4	72.0	9.42
:0.063-2mm	83.3	55.8	65.6	15.4
: <0.063 mm	72.7	70.6	71.6	1.05
SITE NA-1 : total	120	110	115	5.03
:0.063-2mm	114	104	110	5.13
: <0.063 mm	108	100	105	4.36
SITE MA-2 : total	144	135	140	4.51
:0.063-2mm	157	139	148	9.02
: <0.063 mm	177	153	163	12.7
SITE BB-10 : total	142	81.9	109	30.6
:0.063-2mm	138	126	133	6.11
: <0.063 mm	87.8	77.1	82.6	5.36

* 3 SAMPLES FOR EACH PARTICLE SIZE FOR EACH SITE

+ MEDIAN VALUE

TABLE 3
SUMMARY OF METALS IN LEACHATE EXTRACTS *

		(mg/L)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
ARSENIC				
SITE MS-1 : total	0.0011	0.0011	0.0011	0.0000
:0.063-2mm	0.0013	0.0010	0.0011	0.0002
: <0.063 mm	0.0009	0.0007	0.0008	0.0001
SITE NA-1 : total	0.0012	0.0008	0.0010	0.0002
:0.063-2mm	0.0006	0.0006	0.0006	0.0000
: <0.063 mm	0.0015	0.0009	0.0013	0.0003
SITE MA-2 : total	0.0013	0.0011	0.0012	0.0001
:0.063-2mm	0.0012	0.0009	0.0011	0.0002
: <0.063 mm	0.0013	0.0012	0.0012	0.00006
SITE BB-10 : total	0.015	0.013	0.014	0.001
:0.063-2mm	0.0094	0.0084	0.0091	0.0006
: <0.063 mm	0.017	0.017	0.017	0.000
CADMIUM				
SITE MS-1 : total	0.0023	0.0017	0.0019	0.0003
:0.063-2mm	0.0040	0.0015	0.0024	0.0014
: <0.063 mm	0.0039	0.0016	0.0026	0.0012
SITE NA-1 : total	0.0040	0.0012	0.0029	0.0015
:0.063-2mm	0.0064	0.0036	0.0049	0.0014
: <0.063 mm	0.0040	0.0040	0.0040	0.0000
SITE MA-2 : total	0.0054	0.0043	0.0047	0.0006
:0.063-2mm	0.0042	0.0029	0.0038	0.0008
: <0.063 mm	0.0034	0.0016	0.0024	0.0009
SITE BB-10 : total	0.0031	0.0011	0.0022	0.0010
:0.063-2mm	0.0024	0.0022	0.0023	0.0001
: <0.063 mm	0.0030	<0.0010	<0.0010+	-

TABLE 3 (CONTINUED)

		(mg/L)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
CHROMIUM				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
COPPER				
SITE MS-1 : total	0.0040	0.0030	0.0033	0.0006
:0.063-2mm	0.0030	0.0030	0.0030	0.0000
: <0.063 mm	0.0040	0.0020	0.0030	0.0010
SITE NA-1 : total	0.0050	0.0040	0.0043	0.0006
:0.063-2mm	0.0070	0.0050	0.0060	0.0010
: <0.063 mm	0.0070	0.0050	0.0057	0.0012
SITE MA-2 : total	0.0060	0.0020	0.0037	0.0021
:0.063-2mm	0.0040	0.0040	0.0040	0.0000
: <0.063 mm	0.0050	0.0030	0.0040	0.0010
SITE BB-10 : total	0.0060	0.0050	0.0053	0.0006
:0.063-2mm	0.0050	0.0050	0.0050	0.0000
: <0.063 mm	0.0150	0.0050	0.0083	0.0058

TABLE 3 (CONTINUED)

METAL	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV.
IRON				
SITE MS-1 : total	<0.05	<0.05	<0.05	-
:0.063-2mm	<0.05	<0.05	<0.05	-
: <0.063 mm	<0.05	<0.05	<0.05	-
SITE NA-1 : total	<0.05	<0.05	<0.05	-
:0.063-2mm	<0.05	<0.05	<0.05	-
: <0.063 mm	<0.05	<0.05	<0.05	-
SITE MA-2 : total	<0.05	<0.05	<0.05	-
:0.063-2mm	<0.05	<0.05	<0.05	-
: <0.063 mm	<0.05	<0.05	<0.05	-
SITE BB-10 : total	<0.05	<0.05	<0.05	-
:0.063-2mm	<0.05	<0.05	<0.05	-
: <0.063 mm	<0.05	<0.05	<0.05	-
LEAD				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA:2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 3 (CONTINUED)

		(mg/L)		
METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
MAGNESIUM				
SITE MS-1 : total	1080	1050	1070	17.3
:0.063-2mm	1100	1050	1080	26.5
: <0.063 mm	1070	1020	1040	26.5
SITE NA-1 : total	1100	1040	1067	30.6
:0.063-2mm	1140	982	1074	82.1
: <0.063 mm	1010	927	967	41.6
SITE MA-2 : total	1190	945	1075	123.2
:0.063-2mm	1130	1091	1117	22.5
: <0.063 mm	1090	1080	1083	5.8
SITE BB-10 : total	1210	1140	1170	36.1
:0.063-2mm	1240	1140	1177	55.1
: <0.063 mm	1250	1100	1157	81.4
MANGANESE				
SITE MS-1 : total	0.270	0.091	0.184	0.090
:0.063-2mm	0.370	0.028	0.236	0.183
: <0.063 mm	0.250	0.017	0.149	0.120
SITE NA-1 : total	1.76	0.82	1.09	0.583
:0.063-2mm	1.98	1.56	1.58	0.021
: <0.063 mm	2.70	1.47	2.22	0.656
SITE MA-2 : total	10.2	3.45	5.82	3.80
:0.063-2mm	2.27	1.65	1.91	0.323
: <0.063 mm	2.12	1.89	1.98	0.121
SITE BB-10 : total	0.025	0.017	0.021	0.004
:0.063-2mm	0.023	0.016	0.020	0.004
: <0.063 mm	0.028	0.017	0.022	0.006

TABLE 3 (CONTINUED)

METAL	MAXIMUM	MINIMUM	MEAN	STD. DEV.
	(mg/L)			
MERCURY				
SITE MS-1 : total	<0.00005	<0.00005	<0.00005	-
:0.063-2mm	0.00014	<0.00005	0.00009	0.00005
: <0.063 mm	<0.00005	<0.00005	<0.00005	-
SITE NA-1 : total	<0.00005	<0.00005	<0.00005	-
:0.063-2mm	<0.00005	<0.00005	<0.00005	-
: <0.063 mm	<0.00005	<0.00005	<0.00005	-
SITE MA-2 : total	0.00010	<0.00005	0.00007	0.00003
:0.063-2mm	0.00010	<0.00005	0.00007	0.00003
: <0.063 mm	0.00048	0.00008	0.00022	0.00022
SITE BB-10 : total	0.00006	<0.00005	<0.00005	-
:0.063-2mm	0.00011	0.00007	0.00009	0.00002
: <0.063 mm	0.00014	0.00005	0.00010	0.00005
MOLYBDENUM				
SITE MS-1 : total	0.003	0.003	0.003	-
:0.063-2mm	0.005	0.004	0.004	0.0006
: <0.063 mm	0.003	0.003	0.003	0.0000
SITE NA-1 : total	0.003	0.002	0.002	0.0006
:0.063-2mm	0.003	0.002	0.002	0.0006
: <0.063 mm	0.003	0.003	0.003	0.0000
SITE MA-2 : total	0.007	0.005	0.006	0.0010
:0.063-2mm	0.007	0.006	0.006	0.0006
: <0.063 mm	0.007	0.006	0.007	0.0006
SITE BB-10 : total	0.039	0.030	0.033	0.0050
:0.063-2mm	0.031	0.030	0.030	0.0006
: <0.063 mm	0.030	0.017	0.021	0.0075

TABLE 3 (CONTINUED)

METAL	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV.
NICKEL				
SITE MS-1 : total	0.006	0.005	0.005	0.0006
:0.063-2mm	0.006	0.001	0.004	0.0025
: <0.063 mm	0.006	0.003	0.005	0.0017
SITE NA-1 : total	0.004	0.002	0.003	0.0010
:0.063-2mm	0.006	0.001	0.003	0.0025
: <0.063 mm	0.013	0.004	0.010	0.0050
SITE MA-2 : total	0.009	0.005	0.007	0.0021
:0.063-2mm	0.007	0.006	0.007	0.0006
: <0.063 mm	0.010	0.006	0.008	0.0020
SITE BB-10 : total	0.004	0.002	0.003	0.0010
:0.063-2mm	0.006	0.002	0.004	0.0020
: <0.063 mm	0.005	0.005	0.005	0.0000
ZINC				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	0.018	0.007	0.012	0.006
:0.063-2mm	0.009	0.007	0.008	0.001
: <0.063 mm	0.012	0.007	0.009	0.003
SITE BB-10 : total	0.008	<0.005	<0.005+	-
:0.063-2mm	0.006	<0.005	0.006	0.0006
: <0.063 mm	0.008	<0.005	<0.005+	-

* 3 SAMPLES FOR EACH PARTICLE SIZE FOR EACH SITE

+ MEDIAN VALUE

TABLE 4
SUMMARY OF CHLOROPHENOLS AND PCBs IN SEDIMENTS

	(µg/g dry-weight)			
CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STD. DEV.
Trichlorophenol				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE BB-10 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
Tetrachlorophenol				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE BB-10 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-

TABLE 4
CONTINUED

CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STD. DEV.
	(µg/g dry-weight)			
Pentachlorophenol				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE BB-10 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
Polychlorinated Biphenyls				
SITE MS-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE NA-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE MA-2 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE BB-10 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-

TABLE 5
SUMMARY OF CHLOROPHENOLS AND PCBs IN SEDIMENT LEACHATE EXTRACTIONS

CHARACTERISTIC	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV.
Trichlorophenol				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
Tetrachlorophenol				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 5
CONTINUED

	(mg/L)			
CHARACTERISTIC	MAXIMUM	MINIMUM	MEAN	STD. DEV.
Pentachlorophenol				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
Polychlorinated Biphenyls				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 6
SUMMARY OF PAHs IN SEDIMENTS

	(µg/g dry-weight)			
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
ACENAPHTHENE				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	0.005	<0.005	<0.005+	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE BB-10 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	0.005	<0.005	<0.005+	-
: <0.063 mm	<0.005	<0.005	<0.005	-
ACENAPHTHYLENE				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE BB-10 : total	0.008	0.007	0.0073	0.001
:0.063-2mm	0.010	0.007	0.009	0.002
: <0.063 mm	0.006	<0.005	<0.005+	-

TABLE 6
(CONTINUED)

	(µg/g dry-weight)			
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
ANTHRACENE				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	0.005	<0.005	<0.005+	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	0.021	0.011	0.015	0.005
:0.063-2mm	0.008	0.006	0.007	0.001
: <0.063 mm	0.008	0.006	0.007	0.001
SITE MA-2 : total	0.006	0.005	0.0057	0.001
:0.063-2 mm	0.009	0.008	0.0083	0.001
: <0.063 mm	0.025	0.006	0.014	0.004
SITE BB-10 : total	0.017	0.015	0.016	0.001
:0.063-2mm	0.027	0.016	0.022	0.006
: <0.063 mm	0.013	0.006	0.009	0.004
BENZO(A)ANTHRACENE				
SITE MS-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	0.016	<0.010	<0.010+	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE NA-1 : total	0.030	0.017	0.024	0.007
:0.063-2mm	0.013	0.010	0.011	0.002
: <0.063 mm	0.014	0.010	0.012	0.002
SITE MA-2 : total	0.012	<0.010	0.011	0.001
:0.063-2 mm	0.017	0.012	0.014	0.003
: <0.063 mm	0.018	0.010	0.014	0.004
SITE BB-10 : total	0.036	0.030	0.033	0.003
:0.063-2mm	0.082	0.054	0.066	0.014
: <0.063 mm	0.036	0.016	0.026	0.010

TABLE 6
(CONTINUED)

PAH*	(µg/g dry-weight)			
	MAXIMUM	MINIMUM	MEAN	STD. DEV
BENZO (A) PYRENE				
SITE MS-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE NA-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE MA-2 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE BB-10 : total	0.036	0.030	0.032	0.003
:0.063-2mm	0.079	0.057	0.067	0.011
: <0.063 mm	0.033	<0.020	0.028	0.007
BENZO(B)FLUORANTHENE				
SITE MS-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	0.022	<0.020	<0.020+	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE NA-1 : total	0.033	0.026	0.030	0.004
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	0.022	<0.020	0.021	0.001
SITE MA-2 : total	<0.020	<0.020	<0.020	-
: 0.063-2mm	0.029	0.022	0.025	0.004
:<0.063 mm	0.029	<0.020	0.024	0.005
SITE BB-10 : total	0.063	0.048	0.053	0.008
:0.063-2mm	0.110	0.085	0.094	0.014
: <0.063 mm	0.049	0.028	0.042	0.012

TABLE 6
(CONTINUED)

	(µg/g dry-weight)			
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
BENZO(G,H,I)PERYLENE				
SITE MS-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE NA-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE MA-2 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE BB-10 : total	0.030	0.024	0.026	0.003
:0.063-2mm	0.041	0.029	0.034	0.006
: <0.063 mm	0.021	<0.020	<0.020+	-
BENZO(K)FLUORANTHENE				
SITE MS-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE NA-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE MA-2 : total	<0.020	<0.020	<0.020	-
: 0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE BB-10 : total	0.026	0.021	0.023	0.003
:0.063-2mm	0.054	0.039	0.045	0.008
: <0.063 mm	0.023	<0.020	0.021	0.002

TABLE 6
(CONTINUED)

	(µg/g dry-weight)			
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
CHRYSENE				
SITE MS-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE NA-1 : total	0.034	0.021	0.028	0.007
:0.063-2mm	0.019	0.015	0.017	0.002
: <0.063 mm	0.021	0.014	0.018	0.004
SITE MA-2 : total	0.019	0.017	0.018	0.001
:0.063-2 mm	0.030	0.024	0.028	0.003
: <0.063 mm	0.027	0.016	0.022	0.006
SITE BB-10 : total	0.045	0.039	0.042	0.003
:0.063-2mm	0.083	0.059	0.073	0.012
: <0.063 mm	0.048	0.018	0.031	0.015
DIBENZO(A,H)ANTHRACENE				
SITE MS-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE NA-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE MA-2 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE BB-10 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-

TABLE 6
(CONTINUED)

	(µg/g dry-weight)			
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
FLUORANTHENE				
SITE MS-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	0.017	<0.010	<0.010+	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE NA-1 : total	0.180	0.068	0.116	0.058
:0.063-2mm	0.038	0.028	0.032	0.005
: <0.063 mm	0.040	0.031	0.036	0.005
SITE MA-2 : total	0.029	0.022	0.026	0.004
: 0.063-2mm	0.050	0.044	0.048	0.003
: <0.063 mm	0.055	0.033	0.046	0.012
SITE BB-10 : total	0.110	0.084	0.094	0.014
:0.063-2mm	0.160	0.096	0.125	0.032
: <0.063 mm	0.079	0.034	0.053	0.023
FLUORENE				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	0.017	0.011	0.014	0.003
:0.063-2mm	0.008	0.006	0.007	0.001
: <0.063 mm	0.009	0.007	0.008	0.001
SITE MA-2 : total	0.006	0.005	0.006	0.001
: 0.063-2mm	0.007	0.006	0.006	0.001
: <0.063 mm	0.009	0.007	0.008	0.001
SITE BB-10 : total	0.009	0.008	0.0083	0.001
:0.063-2mm	0.015	0.010	0.013	0.003
: <0.063 mm	0.009	<0.005	<0.005+	-

TABLE 6
(CONTINUED)

PAH*	(µg/g dry-weight) MAXIMUM	MINIMUM	MEAN	STD. DEV
INDENO(1,2,3-C,D)PYRENE				
SITE MS-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE NA-1 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE MA-2 : total	<0.020	<0.020	<0.020	-
:0.063-2mm	<0.020	<0.020	<0.020	-
: <0.063 mm	<0.020	<0.020	<0.020	-
SITE BB-10 : total	<0.020	<0.020	<0.020	-
: 0.063-2mm	0.041	<0.020	0.029	0.011
: <0.063 mm	0.021	<0.020	<0.020+	-
NAPHTHALENE				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	0.009	<0.005	0.007	0.002
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	0.008	<0.005	<0.005+	-
SITE MA-2 : total	0.012	0.007	0.009	0.003
: 0.063-2mm	0.016	<0.005	0.009	0.006
: <0.063 mm	0.010	0.005	0.007	0.003
SITE BB-10 : total	0.011	<0.005	0.008	0.003
: 0.063-2mm	0.012	0.006	0.009	0.003
: <0.063 mm	<0.005	<0.005	<0.005	-

TABLE 6
(CONTINUED)

	(µg/g dry-weight)			
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
PHENANTHRENE				
SITE MS-1 : total	0.007	<0.005	<0.005	-
: 0.063-2mm	0.008	0.005	0.006	0.002
: <0.063 mm	0.005	<0.005	0.005+	-
SITE NA-1 : total	0.074	0.038	0.053	0.019
: 0.063-2mm	0.031	0.022	0.026	0.005
: <0.063 mm	0.031	0.024	0.028	0.004
SITE MA-2 : total	0.023	0.018	0.021	0.003
: 0.063-2mm	0.025	0.022	0.024	0.002
: <0.063 mm	0.037	0.023	0.031	0.007
SITE BB-10 : total	0.052	0.044	0.047	0.004
: 0.063-2mm	0.090	0.050	0.072	0.020
: <0.063 mm	0.043	0.019	0.028	0.013
PYRENE				
SITE MS-1 :total	<0.010	<0.010	<0.010	-
:0.063-2mm	0.016	<0.010	<0.010+	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE NA-1 : total	0.140	0.065	0.096	0.039
:0.063-2mm	0.041	0.028	0.034	0.007
: <0.063 mm	0.043	0.031	0.039	0.007
SITE MA-2 : total	0.027	0.021	0.024	0.004
:0.063-2mm	0.043	0.039	0.041	0.002
: <0.063 mm	0.049	0.029	0.042	0.011
SITE BB-10 : total	0.120	0.092	0.102	0.016
: 0.063-2mm	0.160	0.100	0.130	0.030
: <0.063 mm	0.082	0.035	0.054	0.025

TABLE 7
SUMMARY OF PAHs IN LEACHATE EXTRACTIONS

PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
	(mg/L)			
ACENAPHTHENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
ACENAPHTHYLENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

		(mg/L)		
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
ANTHRACENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
BENZO(A)ANTHRACENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

		(mg/L)		
PAH*	MAXIMUM	MINIMUM	MEAN	STD. DEV
BENZO (A) PYRENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
BENZO(B)FLUORANTHENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

PAH*	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
BENZO(G,H,I)PERYLENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
BENZO(K)FLUORANTHENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

PAH*	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
CHRYSENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
DIBENZO(A,H)ANTHRACENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

PAH*	MAXIMUM	(mg/L) MINIMUM	MEAN	STD. DEV
FLUORANTHENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
FLUORENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

PAH*	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
INDENO(1,2,3-C,D)PYRENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
NAPHTHALENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 7
CONTINUED

PAH*	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
PHENANTHRENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
PYRENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 8
SUMMARY OF ORGANOCHLORINE PESTICIDES IN SEDIMENTS

ORGANOCHLORINE PESTICIDE	MAXIMUM	(µg/g dry-weight) MINIMUM	MEAN	STD. DEV
ALDRIN				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
ALPHA-CHLORDANE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE		(µg/g dry-weight) MAXIMUM	MINIMUM	MEAN	STD. DEV
GAMMA-CHLORDANE					
SITE MS-1	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
DIELDRIN					
SITE MS-1	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10	: total	<0.001	<0.001	<0.001	-
	:0.063-2mm	<0.001	<0.001	<0.001	-
	: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE	(µg/g dry-weight) MAXIMUM	MINIMUM	MEAN	STD. DEV
DDT				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
DDD				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE	(µg/g dry-weight) MAXIMUM	MINIMUM	MEAN	STD. DEV
DDE				
SITE MS-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE NA-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE MA-2 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE BB-10 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
ENDRIN				
SITE MS-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE NA-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE MA-2 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE BB-10 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE	(µg/g dry-weight) MAXIMUM	MINIMUM	MEAN	STD. DEV
ENDOSULFAN-I				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
ENDOSULFAN-II				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE	(µg/g dry-weight) MAXIMUM	MINIMUM	MEAN	STD. DEV
ENDOSULFAN SULFATE				
SITE MS-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE NA-1 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE MA-2 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
SITE BB-10 : total	<0.010	<0.010	<0.010	-
:0.063-2mm	<0.010	<0.010	<0.010	-
: <0.063 mm	<0.010	<0.010	<0.010	-
HEPTACHLOR				
SITE MS-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE NA-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE MA-2 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE BB-10 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE	MAXIMUM	MINIMUM	MEAN	STD. DEV
	(µg/g dry-weight)			
HEPTACHLOR EPOXIDE				
SITE MS-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE NA-1 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE MA-2 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
SITE BB-10 : total	<0.0005	<0.0005	<0.0005	-
:0.063-2mm	<0.0005	<0.0005	<0.0005	-
: <0.063 mm	<0.0005	<0.0005	<0.0005	-
LINDANE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 8
CONTINUED

ORGANOCHLORINE PESTICIDE	(µg/g dry-weight)			
	MAXIMUM	MINIMUM	MEAN	STD. DEV
METHOXYCHLOR				
SITE MS-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE NA-1 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE MA-2 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
SITE BB-10 : total	<0.005	<0.005	<0.005	-
:0.063-2mm	<0.005	<0.005	<0.005	-
: <0.063 mm	<0.005	<0.005	<0.005	-
TOXAPHENE				
SITE MS-1 : total	<0.030	<0.030	<0.030	-
:0.063-2mm	<0.030	<0.030	<0.030	-
: <0.063 mm	<0.030	<0.030	<0.030	-
SITE NA-1 : total	<0.030	<0.030	<0.030	-
:0.063-2mm	<0.030	<0.030	<0.030	-
: <0.063 mm	<0.030	<0.030	<0.030	-
SITE MA-2 : total	<0.030	<0.030	<0.030	-
:0.063-2mm	<0.030	<0.030	<0.030	-
: <0.063 mm	<0.030	<0.030	<0.030	-
SITE BB-10 : total	<0.030	<0.030	<0.030	-
:0.063-2mm	<0.030	<0.030	<0.030	-
: <0.063 mm	<0.030	<0.030	<0.030	-

TABLE 9
SUMMARY OF ORGANOCHLORINE PESTICIDES IN LEACHATE EXTRACTS

ORGANOCHLORINE PESTICIDE	(mg/L)			
	MAXIMUM	MINIMUM	MEAN	STD. DEV
ALDRIN				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 . total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
ALPHA-CHLORDANE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
GAMMA-CHLORDANE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
DIELDRIN				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
DDT				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
DDD				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
DDE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
ENDRIN				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
ENDOSULFAN-I				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
ENDOSULFAN-II				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
ENDOSULFAN SULFATE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
HEPTACHLOR				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
HEPTACHLOR EPOXIDE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
LINDANE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 9
CONTINUED

ORGANOCHLORINE PESTICIDE	(mg/L) MAXIMUM	MINIMUM	MEAN	STD. DEV
METHOXYCHLOR				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
TOXAPHENE				
SITE MS-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE NA-1 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE MA-2 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-
SITE BB-10 : total	<0.001	<0.001	<0.001	-
:0.063-2mm	<0.001	<0.001	<0.001	-
: <0.063 mm	<0.001	<0.001	<0.001	-

TABLE 10
SUMMARY OF GUAIACOLS AND CATECHOLS IN SEDIMENTS*
(µg/g dry-weight)

GUAIACOL/CATECHOL	MAXIMUM	MINIMUM	MEAN	STD.DEV
2,4,5-TRICHLOROGUAIACOL				
MS-1	<0.001	<0.001	<0.001	-
NA-1	0.004	0.003	0.0033	0.0006
MA-2	0.004	0.002	0.003	0.001
BB-10	<0.001	<0.001	<0.001	-
TETRACHLOROGUAIACOL				
MS-1	<0.001	<0.001	<0.001	-
NA-1	0.003	0.002	0.0027	0.0006
MA-2	0.002	0.002	0.002	-
BB-10	<0.001	<0.001	<0.001	-
3,4,5-TRICHLOROCATECHOL				
MS-1	<0.001	<0.001	<0.001	-
NA-1	<0.001	<0.001	<0.001	-
MA-2	<0.001	<0.001	<0.001	-
BB-10	<0.001	<0.001	<0.001	-
TETRACHLOROCATECHOL				
MS-1	<0.001	<0.001	<0.001	-
NA-1	<0.001	<0.001	<0.001	-
MA-2	<0.001	<0.001	<0.001	-
BB-10	<0.001	<0.001	<0.001	-

* THREE SUB-SAMPLES TESTED WERE THE "TOTAL" SAMPLE, NOT A PARTICLE SIZE FRACTION

TABLE 11
SUMMARY OF POLYCHLORINATED DIBENZODIOXINS IN SEDIMENTS*
(pg/g dry-weight)

DIOXIN/SITE	MAXIMUM	MINIMUM	MEAN	STD.DEV
T$_4$CDD - TOTAL				
MS-1	<1.8	<1.3	<1.5+	-
NA-1	3.1	<1.6	<1.9+	-
MA-2	<3.9	<1.9	<2.3+	-
BB-10	<3.3	<2.1	<3.3+	-
2,3,7,8-T$_4$CDD				
MS-1	<1.8	<1.3	<1.5+	-
NA-1	1.9	<1.6	<1.9+	-
MA-2	<3.9	<1.9	<2.3+	-
BB-10	<3.3	<2.1	<3.3+	-
P$_5$CDD - TOTAL				
MS-1	<4.2	<2.6	<3.6+	-
NA-1	3.9	<2.6	<8.3+	-
MA-2	<6.6	<2.9	<4.2+	-
BB-10	<6.3	<1.4	<6.0+	-
1,2,3,7,8-P$_5$CDD				
MS-1	<4.2	<2.6	<3.6+	-
NA-1	1.5	<2.6	<8.3+	-
MA-2	<6.6	<2.9	<4.2+	-
BB-10	<6.3	<1.4	<6.0+	-
H$_6$CDD - TOTAL				
MS-1	<3.1	<2.6	<3.0+	-
NA-1	60.	<4.3	56+	-
MA-2	74.	22.	40.3	29.2
BB-10	42.	<5.8	28.6	19.8
1,2,3,4,7,8-H$_6$CDD				
MS-1	<3.1	<2.6	<3.0+	-
NA-1	<4.3	<0.6	<2.5+	-
MA-2	<6.3	<2.8	<6.3+	-
BB-10	<5.8	<3.4	<5.3+	-

TABLE 11
CONTINUED

DIOXIN/SITE	MAXIMUM	MINIMUM	MEAN	STD.DEV
1,2,3,6,7,8-H_6CDD				
MS-1	<3.1	<2.6	<3.0+	-
NA-1	9.9	<4.3	7.6	2.9
MA-2	14.	<6.3	8.9	4.4
BB-10	6.1	<5.3	<5.8+	-
1,2,3,7,8,9-H_6CDD				
MS-1	<3.1	<2.6	<3.0+	-
NA-1	4.4	<4.3	4.1	0.5
MA-2	<6.3	<2.8	<6.3	-
BB-10	<5.8	<3.4	<5.3+	-
H_7CDD - TOTAL				
MS-1	13.	<4.2	<6.0+	-
NA-1	86.	54.	68.3	16.3
MA-2	170.	82.	114.3	48.4
BB-10	100.	73.	90.3	15.0
1,2,3,4,6,7,8-H_7CDD				
MS-1	5.8	<4.2	<6.0+	-
NA-1	45.	3.2	25.1	21.0
MA-2	81.	40.	53.7	23.7
BB-10	49.	35.	42.3	7.0
O_8CDD				
MS-1	85.	33.	53.7	27.6
NA-1	340	190	257	76.4
MA-2	540	320	400	20.0
BB-10	260	200	233	30.6

+MEDIAN VALUE

* THREE SUB-SAMPLES TESTED WERE THE "TOTAL" SAMPLE, NOT A PARTICLE SIZE FRACTION

TABLE 12
SUMMARY OF POLYCHLORINATED DIBENZOFURANS IN SEDIMENTS*
(pg/g dry-weight)

FURAN/SITE	MAXIMUM	MINIMUM	MEAN	STD.DEV
T_4CDF - TOTAL				
MS-1	<2.1	<1.2	<1.8+	-
NA-1	38.	8.7	27.9	16.6
MA-2	25	14	17.7	6.4
BB-10	6.2	<3.4	4.3	1.7
2,3,7,8-T_4CDF				
MS-1	<2.1	<1.2	<1.8+	-
NA-1	26.	5.8	17.6	10.5
MA-2	15	8.9	11.1	3.4
BB-10	6.2	<3.4	4.3	1.7
P_5CDF - TOTAL				
MS-1	<1.8	<1.2	<1.4+	-
NA-1	1.3	<1.4	<1.7+	-
MA-2	<2.5	<1.2	<1.5+	-
BB-10	3.6	<2.0	<3.2+	-
1,2,3,7,8-P_5CDF				
MS-1	<1.8	<1.2	<1.4+	-
NA-1	<1.7	<0.4	<1.4+	-
MA-2	<2.5	<1.2	<1.5+	-
BB-10	<3.2	<0.8	<2.0+	-
2,3,4,7,8-P_5CDF				
MS-1	<1.8	<1.2	<1.4+	-
NA-1	<1.7	<0.4	<1.4+	-
MA-2	<2.5	<1.2	<1.5+	-
BB-10	<3.2	<0.8	<2.0+	-

TABLE 12
(CONTINUED)

FURAN/SITE	MAXIMUM	MINIMUM	MEAN	STD.DEV
H_6CDF - TOTAL				
MS-1	<2.3	<2.1	<2.2+	-
NA-1	19.	<2.2	<2.2+	-
MA-2	57.	<2.3	<2.8+	-
BB-10	11.	<3.8	<4.1	-
1,2,3,4,7,8-H_6CDF				
MS-1	<2.3	<2.1	<2.2+	-
NA-1	<2.2	<0.6	<2.2+	-
MA-2	<4.9	<2.3	<2.8+	-
BB-10	<4.1	<1.5	<3.8	-
1,2,3,6,7,8-H_6CDF				
MS-1	<2.3	<2.1	<2.2+	-
NA-1	<2.2	<0.6	<2.2+	-
MA-2	<4.9	<2.3	<2.8+	-
BB-10	<4.1	<1.5	<3.8	-
2,3,4,6,7,8-H_6CDF				
MS-1	<2.3	<2.1	<2.2+	-
NA-1	<2.2	<0.6	<2.2+	-
MA-2	<4.9	<2.3	<2.8+	-
BB-10	<4.1	<1.5	<3.8	-
1,2,3,7,8,9-H_6CDF				
MS-1	<2.3	<2.1	<2.2+	-
NA-1	<2.2	<0.6	<2.2+	-
MA-2	<4.9	<2.3	<2.8+	-
BB-10	<4.1	<1.5	<3.8	-
H_7CDF - TOTAL				
MS-1	<4.3	<3.5	<3.8+	-
NA-1	45.	25.	33.3	10.4
MA-2	110	33	59.7	43.6
BB-10	36	25	30.3	5.5

TABLE 12
(CONTINUED)

FURAN/SITE	MAXIMUM	MINIMUM	MEAN	STD.DEV
1,2,3,4,6,7,8-H_7CDF				
MS-1	<4.3	<3.5	<3.8+	-
NA-1	17.	12.	13.7	2.9
MA-2	31.	13.	19.	10.4
BB-10	18.	11.	14.	3.6
1,2,3,4,7,8,9-H_7CDF				
MS-1	<4.3	<3.5	<3.8+	-
NA-1	<3.6	<0.7	<3.1+	-
MA-2	<5.1	<2.7	<3.3+	-
BB-10	<4.6	<1.6	<4.2+	-
O_8CDF				
MS-1	<7.2	<5.0	<6.4+	-
NA-1	30	<13	20.3	8.7
MA-2	72	14	35.	32.1
BB-10	26	<17	20.3	4.5

+MEDIAN VALUE

* THREE SUB-SAMPLES TESTED WERE THE "TOTAL" SAMPLE, NOT A PARTICLE SIZE FRACTION

TABLE 13

SUMMARY OF MICROTOX ACUTE TOXICITY BIOASSAY RESULTS (EC50)

SAMPLE LOCATION/ SIZE FRACTION	REPLICATE #1	REPLICATE #2	REPLICATE #3
SITE MS-1: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
SITE NA-1: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
SITE MA-2: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
SITE BB-10: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC

NOTES:

1. READINGS WERE TAKEN AFTER 5 AND 15 MINUTES OF EXPOSURE.

TABLE 14

SUMMARY OF SAND DOLLAR CHRONIC TOXICITY BIOASSAY RESULTS (FID50)

SAMPLE LOCATION/ SIZE FRACTION	REPLICATE #1	REPLICATE #2	REPLICATE #3
SITE MS-1: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
SITE NA-1: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
SITE MA-2: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
: <0.063 mm	NON-TOXIC	NON-TOXIC	NON-TOXIC
SITE BB-10: total	NON-TOXIC	NON-TOXIC	NON-TOXIC
:0.063-2mm	NON-TOXIC	NON-TOXIC	12.49%
: <0.063 mm	NON-TOXIC	11.23%	79.6%

NOTES:

1. EACH BIOASSAY WAS COMPOSED OF EIGHT CONCENTRATIONS IN TRIPLICATE, WITH A CONTROL AT THE BEGINNING AND END OF THE SERIES.

2. CONTROL FERTILIZATION CRITERIA WERE SET AT 85%, WITH ANY READINGS OUTSIDE OF THE RANGE REPEATED. RESULTS WERE DETERMINED FIRST BY ESTABLISHING IF THERE WERE SIGNIFICANT DIFFERENCES BETWEEN CONTROL AND CONCENTRATIONS.

3. COPPER WAS USED AS A REFERENCE TOXICANT, WITH A MEAN FID50 OF 0.06 PPM. CADMIUM AND DEHYDROABIETIC ACID WERE ALSO USED, BUT PROBLEMS WERE ENCOUNTERED FOR EACH. THE DHA PRECIPITATED IN SEAWATER, WHILE THE CADMIUM SEEMED TO CAUSE ABNORMAL EGG FORMATIONS WHICH MADE DISTINGUISHING FERTILIZED AND UN-FERTILIZED EGGS DIFFICULT.

TABLE 15

THE QUANTITY OF METALS LEACHED FROM SEDIMENTS ON THE BASIS OF INITIAL SEDIMENT CONCENTRATION

			MG/L PER µG/G			
SITE	ARSENIC	CADMIUM	COPPER	MERCURY	NICKEL	ZINC
MS-1			0.00004		0.00009	
			0.00004		0.00011	
NA-1			0.00008		0.00005	
			0.00008		0.00018	
MA-2		0.0069	0.00004		0.00010	0.00005
		0.0041	0.00004	0.0010	0.00011	0.00006
BB-10	0.00089	0.0034	0.00007		0.00008	0.00074
	0.00173	0.0014	0.00018		0.00015	

NOTES:

1. THE VALUES IN THIS TABLE WERE CALCULATED BY DIVIDING THE MEAN CONCENTRATIONS REPORTED IN TABLE 3 BY THE MEAN CONCENTRATION FOR THE SAME PARTICLE SIZE IN TABLE 2. BEFORE PERFORMING THIS CALCULATION, THE MEAN CONCENTRATIONS IN TABLE 3 WERE CORRECTED BY SUBTRACTING THE HIGHEST REPORTED CONCENTRATION OF THAT METAL IN THE SEAWATER BLANK.

2. FOR EACH SITE, THE TOP VALUE IS FOR THE PARTICLE SIZE RANGE FOR 0.063 MM TO 2 MM, WHILE THE SECOND VALUE IS FOR PARTICLES LESS THAN 0.063 MM IN SIZE. BLANKS IN THE TABLE REPRESENT CASES WHERE THE CONCENTRATION IN THE SEDIMENT OR EXTRACT WERE LESS THAN THE ANALYTICAL DETECTION LIMIT, OR WHERE EXTRACT CONCENTRATIONS WERE EQUAL TO OR LESS THAN THE HIGHEST CONCENTRATION MEASURED IN THE SEAWATER BLANK.